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Future of Earth

Investing in solutions for a more sustainable planet

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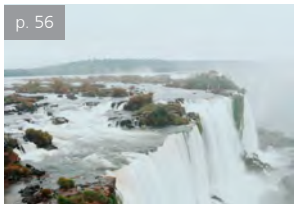
p. 56



Water

While 71% of the Earth is covered by water, only 2.5% of the world's water is freshwater, with 69% of that locked in glaciers or frozen ice caps. See chapter 5 to understand the challenge of water scarcity and how it can be solved.

The executive summary (chapter 1) begins on the next page. Each subsequent chapter is structured to provide commentary on three categories: **the time is now, solutions for the future,** and **where to invest.**

p. 14

People, health, and communities

Air pollution is the fourth leading cause of death worldwide. Plus, some of the world's richest cities are sinking. See chapter 2 to learn about managing risks to human health and our communities.

p. 13

Interview with Jane Goodall, PhD, DBE

Where to invest: the investment opportunities around these solutions that are most relevant to private investors and their portfolios

p. 55

Interview with Suzy Amis Cameron

p. 24

Interview with Dr. Kamran Khan

The time is now: the challenges and drivers that shape the world we live in and the investments we make

Interview with Dr. Robert Steinberger-Wilckens

p. 42

Solutions for the future: the innovations and technologies that will help solve the Earth's most pressing challenges

p. 44

Land

An estimated 21–37% of total emissions are attributable to the food system, but plant- and lab-based meats will be part of the food revolution. See chapter 4 to learn about solutions to help preserve land and biodiversity.

p. 30

Energy

Which region is leading the shift to sustainable energy? Find the answer, along with a discussion of how innovation in the energy sector can help us reach carbon reduction targets, in chapter 3.

Pexels / Johannes Rapprich

Executive summary

Throughout history, human ingenuity has prevailed in the face of numerous challenges. One recent example is the rapid development of the COVID-19 vaccine. Looking to the future, one of the biggest hurdles we face is what economists have called the "environmental credit crunch." Our current standard of living and overall level of consumption are unsustainable in relation to our planet's finite natural resources. As global citizens, consumers, and investors, we are stewards of the Earth. We have the power to shape a more sustainable path that will allow us to continue to evolve our quality of life while preserving our planet for the next generation. The "Future of Earth" rests with us. In this report, we discuss how investing in the future of our planet can yield financial, social, and environmental benefits.

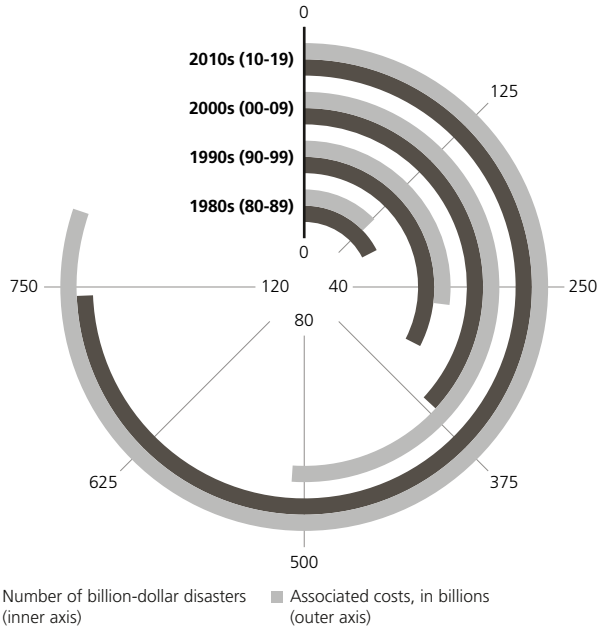
See endnotes on page 66.

Over the past few decades, human creativity and innovation have continually improved global living standards. The number of people living in extreme poverty has more than halved in the last 30 years; life expectancies have roughly doubled in the past century; and technological advances have vastly enhanced productivity and expanded access to critical goods and services. But rising living standards carry an environmental cost, and we now face a number of challenges as a result: from diminishing natural resources to increasingly frequent extreme weather events. The toll is not merely environmental; climate change poses significant health consequences and risks to our communities as well.

Urgent action is needed to combat the growing climate crisis. A coordinated effort between the public and private sectors will be critical to solving the challenges ahead. For investors, the transition to a more sustainable future presents both risks and opportunities. While climate change is a rising source of uncertainty in assessing asset values, more companies are endeavoring to reduce their environmental footprint and be better positioned for the future. Those that are innovating to solve climate-related challenges will enjoy robust long-term growth prospects.

Figure 1

The economic costs of environmental disasters



Source: NOAA, UBS, 2021

The challenges we face

From extreme weather to unsafe air quality, the environmental and human toll of climate change has become apparent. Natural disasters caused an economic loss of USD 268 billion globally in 2020, according to Aon.[1] In the US alone, 22 natural disaster events took a financial toll of more than USD 1 billion each, a new annual record and double the number recorded in 2019.[2]

These numbers are likely a fraction of the total cost that may be attributable to climate change. Beyond the economic impact, climate change is linked to illness, inequality, and loss of life for some segments of the population. In fact, air pollution is one of the top five most common causes of death globally. As urbanization trends unfold in emerging markets, air quality in some of the most populous areas of the world is becoming an increasing concern. Rising sea levels and temperatures in coastal areas are also posing a threat to disparate communities.

The time is now

The accumulating evidence of the threats of climate change is spurring a call to action, and opportunities exist for those who embrace and address these challenges. A report by the OECD[3] makes the case that governments can promote sustainable growth through both strong fiscal support and coherent climate policy, combined with investments in low-emission technologies, energy efficiency, and climate-resilient infrastructure. The report estimates that this type of climate mitigation initiative could increase long-run output by up to 2.8% on average across G20 economies in 2050.

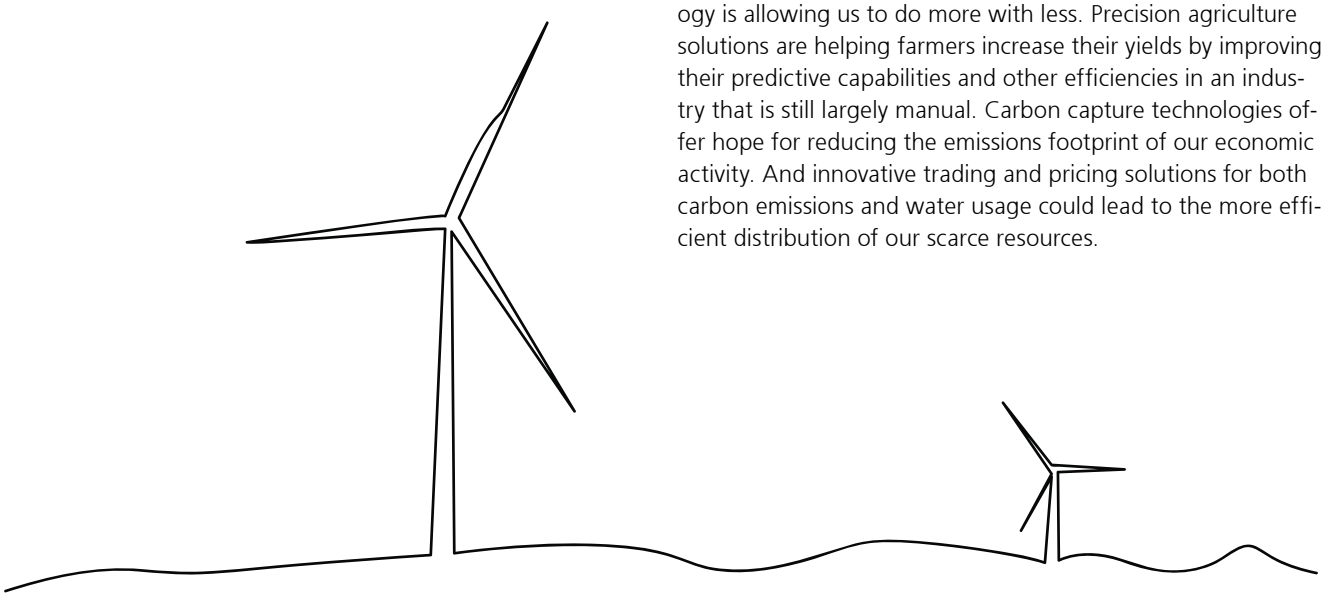
The urgency of the economic and human health challenges we face should incentivize lawmakers and business leaders to accelerate the transition to a sustainable future. On the bright side, we are already seeing significant momentum in climate change mitigation. Growing regulatory support, improving economics for technology-based solutions, and shifting consumer and investor preferences are all converging to form a significant catalyst to push sustainability forward.

See endnotes on page 66.

Regulatory environment is becoming more supportive
The all-encompassing fallout of the COVID-19 pandemic has offered the world a unique opportunity to rebuild the economy in a more sustainable manner. As governments look to kick-start their recoveries, green spending has become one avenue for doing so, adding to the policy momentum that was already underway.

While regional differences remain, some of the world's largest economies, including the US, China, Japan, and the European Union (EU), have announced plans to transition to carbon neutrality. To this end, governments are looking to increase their use of renewable energy and support the transition to green solutions like electric vehicles. The EU's fiscal stimulus package worth EUR 1.85 trillion dedicates roughly 30% of the capital to climate investment, and the balance of 70% to projects that adhere to strict environmental regulations. Similarly, China and Japan have emphasized plans to decarbonize by deploying renewable energy and transitioning to electric transport. In the US, the new administration has made addressing climate change a top priority. President Joe Biden has re-entered the US in the Paris Climate Agreement and has set a goal of achieving carbon neutrality by 2050.

Stricter environmental regulations will lead to winners and losers across sectors, as incumbents will be forced to innovate or experience higher regulatory costs, and as new, innovative climate-focused enterprises offering sustainable products and services emerge.



While regional differences remain, some of the world's largest economies, including the US, China, Japan, and the European Union (EU), have announced plans to transition to carbon neutrality.

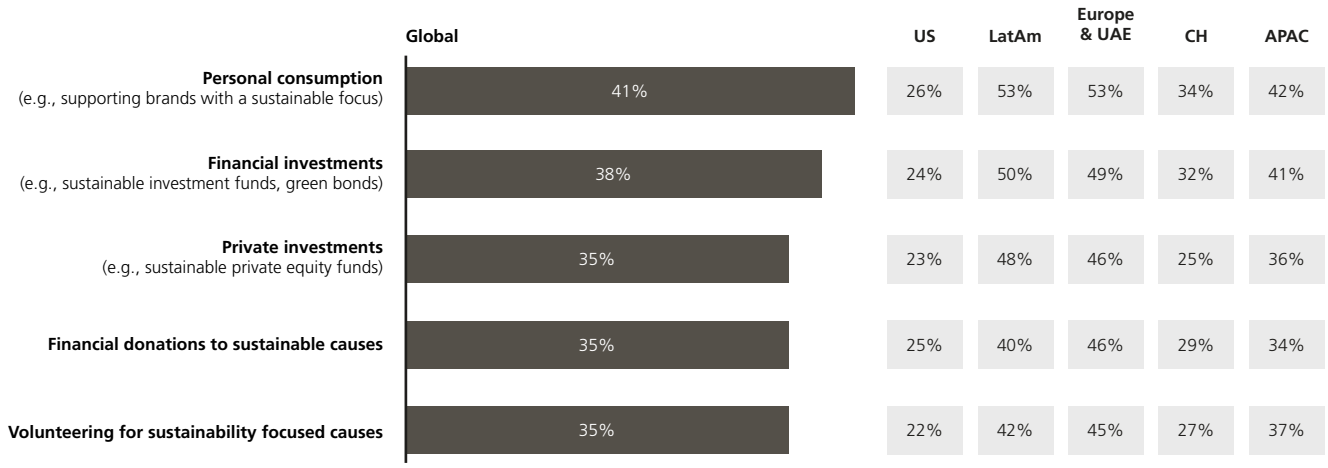
Technology is improving
While the rising economic costs of inaction are enough incentive to invest in sustainability solutions, the improved economics of critical technologies should also help attract investment and accelerate the transition to carbon neutrality. The cost of electricity generation using wind and solar technologies has fallen substantially and lessened the industry's reliance on tax incentives and policy support. Wind and solar are now the cheapest sources of electricity generation in certain regions of the world.

At the same time, battery technology has advanced both for renewable energy storage and for electric vehicles. More advanced storage solutions should help solve the primary weakness of solar and wind generation: their variability. In addition, falling battery costs and improved technology lower two major impediments to electric vehicle adoption: vehicle cost and battery range. The battery is just one example of how technology is allowing us to do more with less. Precision agriculture solutions are helping farmers increase their yields by improving their predictive capabilities and other efficiencies in an industry that is still largely manual. Carbon capture technologies offer hope for reducing the emissions footprint of our economic activity. And innovative trading and pricing solutions for both carbon emissions and water usage could lead to the more efficient distribution of our scarce resources.

See endnotes on page 66.

Figure 2

Preferred ways of engaging in sustainability



Source: UBS Investor Sentiment 4Q20. Based on an online survey of investors with USD 1mn+ in investable assets and business owners with USD 1mn+ in annual revenue and at least one other employee. Sample size of 4,005 includes US, 1,400; Latin America, 600; Europe and the UAE, 1,002; Switzerland, 202; and Asia Pacific, 801.

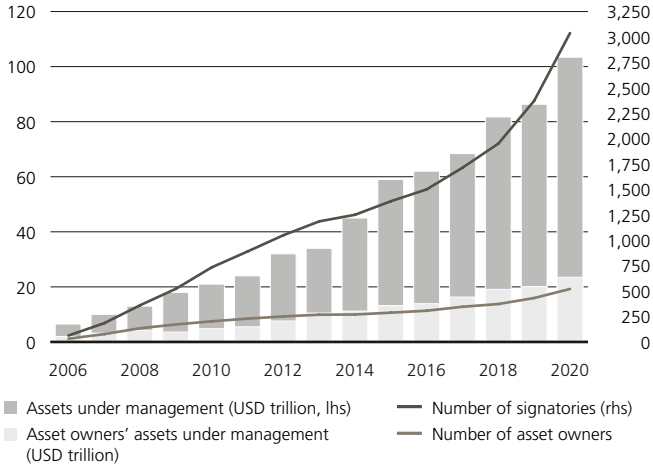
Consumers, companies, and investors are taking notice

As awareness of climate challenges grows, consumers, companies, and investors are increasingly incorporating sustainability considerations into their decisions. A number of studies indicate that younger consumers are more environmentally conscious than prior generations. We are already seeing evidence of this trend. Roughly half of millennials in the US consume plant-based meat at least once a month, versus just 20% of baby boomers, and millennials were more likely than older generations to state "better for the environment" as their reason for doing so.[4] As millennials continue to enjoy their peak earnings years, and as Generation Z enters the labor force, these two cohorts will be increasingly relevant for consumer purchasing trends.

Meanwhile, corporations are acknowledging the need to address climate concerns in order to adhere to certain environmental, social, and governance (ESG) standards, or risk missing out on capital flows. We are seeing a rising number of private sector initiatives to tackle climate challenges, partly enabled by sustainable finance, which has become an integral part of global capital markets over the past decade. This rapid growth in dedicated assets and the proliferation of investable products have come about thanks to policy and regulatory initiatives as well as strong market interest and appetite for sustainability-linked assets.

Figure 3

Growth of sustainable investing assets and UN PRI signatories



Source: United Nations Principles for Responsible Investment, 2020
Accessed via https://www.unpri.org/pri/about-the-pri

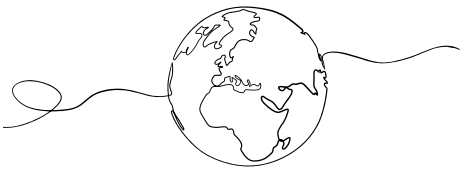
See endnotes on page 66.

The development of the global sustainable finance system has given investors a new voice and means to direct their capital toward supporting a more sustainable future. Not only are investors aligning their climate and financial goals with investment term sheets, but they are also actively engaging with companies to drive transition strategies, catalyzing investment dollars and encouraging corporations to become part of the solution.

The opportunity for a better future

Global corporations, due to the scale and carbon intensity of their operations, have a role to play as well. There are two primary ways corporations can contribute to sustainability in a positive way. One is by improving the sustainability of their operations, for example by reducing waste, transitioning to renewable energy sources, or improving the efficiency of resource utilization. Another is by providing products and services that can help facilitate a greener economy.

A range of sustainable and thematic investment strategies can help investors integrate these corporate-level considerations into their portfolio. Thematic investments typically target companies with revenue exposure to unique or innovative products and services, while sustainable investment strategies consider company operations alongside a number of environmental, social, and governance factors. Notably, thematic and sustainable investments often overlap, and many strategies will consider both of these factors in their investment analysis. On the next page we give a brief preview of the thematic solutions that are embedded throughout the following chapters, and provide high-level context on how sustainable investment strategies integrate ESG factors into the investment process.



SDG 13: Climate action
Take urgent action to combat climate change and its impact

Source: https://sdgs.un.org

SI themes in focus
A UBS Investor Sentiment survey found that the top three themes in focus for sustainable investments globally are healthcare, clean water, and climate change.

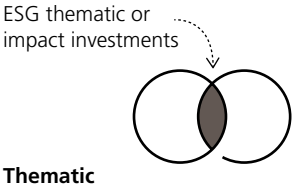
51%
healthcare

51%
clean water

50%
climate change

Source: UBS Investor Sentiment 4Q20
Note: Percentage of survey respondents who indicated they would want to invest in these themes. See Fig. 2 source on previous page for additional information.

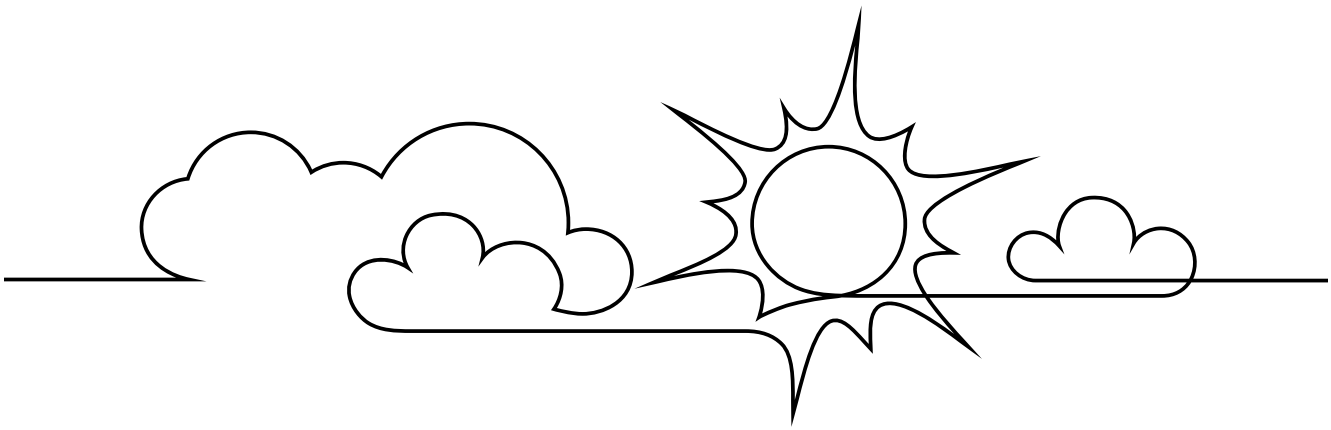
Investment strategies
Thematic and sustainable investments often overlap



Thematic
Investing in societal, resource and technological trends

Sustainable
Incorporating broad ESG considerations and in some cases targeting measurable impact outcomes

See endnotes on page 66.



Thematic: Investing in problem-solvers
Innovative approaches to solving sustainability challenges have become not only more prevalent in recent years, but also more economically viable, and we believe some of these solutions offer significant growth potential for investors.

In **Chapter 2,** we discuss how climate change affects our health and communities, and how it exacts a toll on economies and societies. Air pollution can lead to respiratory and cardiovascular disease and is linked to certain forms of cancer. While stemming pollution at the source through smart urban planning and emissions reduction is an ideal way to reduce the rates of climate-linked disease, select healthcare companies that provide treatment for these diseases could also benefit.

In the next three chapters, we explore three critical resources—energy, land, and water—that are heavily affected by climate change and, as a result, present the biggest opportunities for change and investment.

In **Chapter 3,** we delve into our energy future and discuss the opportunity for renewable energy, storage solutions, and the role nuclear energy and natural gas will play in the years ahead. We see opportunities in a diverse portfolio of emerging technologies, including renewable energy, hydrogen, fuel cells, batteries, biofuels, and carbon capture technologies. In our view, no single technology is likely to offer a one-stop solution; instead, we expect a combination of new, lower-emissions technologies and a diverse array of energy providers to aid in the transition.

In **Chapter 4,** we discuss the need to feed a growing population, which results in a threat to forests and biodiversity and the viability of arable land. We turn to innovative technologies to help reduce the carbon footprint of agriculture: From drone spraying and satellite data that can aid in climate mitigation planning, to vertical farming and alternative proteins, we see a number of opportunities in companies that can aid in sustainable farming.

Finally, **Chapter 5** takes a look into the growing challenge of water scarcity. The water sector is turning to digital tools and data analytics to improve efficiencies. Cloud platforms can be used to aid in the management of water plant networks, and sensors can detect leakage, a significant source of wasted water, in real time.

See endnotes on page 66.

ESG integration: Looking under the hood
Considering environmental factors in investment analysis can help mitigate climate risk in portfolios over time. Companies that lead their peers in addressing environmental challenges are less likely to face pressure from more stringent regulations, and they are also less exposed to reputational risk as consumers begin to take more notice of sustainability initiatives. Climate change poses a risk to companies' operations, cost of capital, and profitability—take, for example, higher costs of water for a water-intensive business following a drought, or the growing cost to insurers of frequent natural disasters.

Successfully managing ESG factors can also be a competitive advantage. Being ahead of the curve in addressing climate challenges is indicative of the long-term viability of a company's business model. For example, as climate initiatives are incorporated into oil and gas business plans, leading energy firms that are welcoming or even accelerating the transition to renewables can tap into higher-growth markets and do better than their peers in managing the fallout from falling fossil fuel demand.

Selecting companies that lead in environmental management is one way to factor environmental data into investment strategies. Investing in ESG improvers or in engagement strategies offers additional avenues. ESG improver strategies aim to select companies with management teams who are actively improving upon their environmental strategies, or those who are making significant changes to improve the sustainability of their business model. Meanwhile, ESG engagement strategies look to work directly with the company to facilitate change and to address sustainability shortfalls.

▸ **Global household wealth**
Mobilizing even just 1% of global household wealth would help bridge the estimated USD 2.5 trillion of annual investments required to achieve the UN SDGs.

USD 230–400 trillion today

A collaborative approach is needed

As we look to the future, it is clear that in order to protect our livelihoods, our economies, and our Earth, the sustainability transition is imperative. This presents not only risks for investors to be mindful of, but also an opportunity for them to play a major role in funding the solutions. Global household wealth today has reached USD 230–400 trillion, according to various studies, and mobilizing even just 1% of it every year would help bridge the estimated USD 2.5 trillion of annual investments required to achieve the United Nations' Sustainable Development Goals (SDGs).[5] Effort will also be needed across the private sector to align corporate behavior and operations more closely to the principles of sustainable development.

In the following pages, we address what we see as key considerations in a large and growing universe of sustainability opportunities. We focus in particular on how private individuals can use their investment capital to generate market-rate financial returns, capture growing market opportunities, and align the purpose of their wealth with their personal values. The financial services industry also has a role to play in identifying such opportunities and enabling access for additional private capital through investment funds or direct investments in public and private companies. The focus on solutions with optimal risk and return means that investors can engage with sustainable investments as part of their conventional returns-driven portfolios, which allows for greater scale of capital.

Although not in the scope of this report, philanthropic investments are an additional avenue private investors could pursue to generate positive environmental and social impact. Blended finance structures in particular allow combining returns-driven private capital with either public sector or philanthropic funds, to deliver measurable sustainable outcomes at concessionary financial returns. Charitable contributions to companies and organizations that further sustainable development, often with regional focus, are another way to channel funding where it is most needed.

See endnotes on page 66.

Sustainable development and the UN SDGs

The issue of sustainable development is one of balance and security: how to address the increasing demand for limited resources coming from an ever-growing population. This includes having enough energy to keep our economies and lives running at full speed, producing enough food for everyone to eat, and ensuring we have access to enough safe drinking water. The nature of these challenges makes sustainable development a global issue that requires a global response.

To address these issues, the UN launched the 2030 Agenda for Sustainable Development with the support of its member states. Its purpose, among other things, was to end poverty, combat climate change, and fight injustice—issues that affect developed and developing economies and nations around the world. Aligned to these areas of focus, the SDGs came into effect in January 2016. This ambitious set of 17 goals recognizes the traditional forms of capital—physical, human, and land (also known as environmental capital, in today's terms)—while acknowledging that social and legal structures play an important role in determining their effectiveness.

Over the past five years, the SDGs have become a catalytic call to action, a way to raise awareness, measure progress, and engage public and private capital in sustainable development. Sustainable investing in general, and impact investing in particular, have emerged as a preferred way for private investors to contribute to tangible environmental and social outcomes while generating financial returns. When identifying solutions that further sustainable development—whether in private markets or in SDG-related engagements with public companies—we would encourage investors to clearly assess whether their capital directly addresses one or several of the 169 underlying targets beneath the 17 SDGs. The targets help pinpoint where public and private capital can be most catalytic and instrumental to moving the needle. Investors could also choose to simply signal their preference for companies that actively address sustainability in a more high-level alignment to the 2030 Agenda as part of their sustainable investments.

Recognizing that climate change is potentially the largest single threat to our civilization, 196 nations signed an international treaty in 2015 to limit global warming to well below 2, preferably 1.5, degrees Celsius compared to pre-industrial levels—the so-called Paris Agreement. While not necessarily a scientific target, 2 degrees is the threshold deemed necessary to avoid the most catastrophic consequences of climate change, including rising sea levels, harmful alterations to ecosystems, stress on water systems due to drought, greater incidence of waterborne disease from floods, increased occurrence of wildfires, higher rate of heat-related deaths, and increased occurrence of respiratory disease from poor air quality. Although initially adopted by governments, companies and consumers have begun recognizing that they play a major role in achieving the Paris targets, evident in the rise in carbon-neutral corporate pledges and sustainable consumption behaviors.

- **Investing to address the UN SDGs**
  Throughout this report, we have identified areas where private investors could support the achievements of the UN SDGs by either financing direct solutions to the underlying SDG targets or by signaling investor preference for companies who actively address sustainability.

Find the specific SDGs alongside "Where to invest" sections within each chapter.

See endnotes on page 66.

External view

Jane Goodall, PhD, DBE

Founder of The Jane Goodall Institute and UN Messenger of Peace

Dr. Goodall, how does climate change impact the security of our planet and our civilization? What can governments and individuals do, and what role can investors play, to address this challenge?

We are still battling the effects of a pandemic that we have brought upon ourselves by our total disregard of the natural world. And it is this disregard for the natural world that has caused the far greater threats to the future of life on Earth: climate change and loss of biodiversity. Already we are seeing changing weather patterns, longer droughts, out-of-control fires, more frequent [destructive] storms, sea-level rise, and more severe flooding. Increasing numbers of climate refugees are leading to mass protests and human rights abuses in many countries. We must get together to tackle climate change—governments, businesses, NGOs, and all citizens. We must develop a new mind set—there cannot be unlimited economic development on a planet with finite natural resources and growing human populations. Fossil fuels must be left in the ground, forests and oceans should be protected, and we should move toward a plant-based diet. As individuals, we can reduce unsustainable lifestyles, refuse to buy products made unethically, and stand by decisions made by governments to protect the environment. We must alleviate poverty, for the poor cannot afford the luxury of making ethical choices; they have to do whatever they can to survive. Investments should be made in renewable energy, transforming industrial agriculture into family farms and permaculture, working toward a circular economy, lifting people from poverty, and universal education.

Why is the threat to biodiversity a threat to humanity? What lessons have you learned from your decades of observing nature and conservation efforts? How can we do better as individuals, and can technology help in safeguarding biodiversity?

Humans are not only part of the natural world, but we depend on it for air, water, food, clothing, shelter—for everything. But we depend on healthy ecosystems. I learned in the rainforest how everything is interconnected in the tapestry of life and every species has a role to play. When a species becomes extinct, a hole is torn in that tapestry; and when it becomes too tattered, the whole ecosystem may collapse—a disaster for those who depended on it for their livelihood. In my 87 years, we have massively damaged the natural world. Agricultural chemicals have greatly reduced insect populations, which has affected the birds and small mammals that rely on them, which has affected the predators. The soil is being killed. Human health has been compromised. Wildlife trafficking—for food, medicine, skins, and pets—is bringing some species close to extinction. Pollution and overfishing are bringing many fish species and other aquatic life close to extinction, causing terrible hardship to the millions who depend on them. We must alleviate poverty and help local communities find ways of living that do not destroy their environment, [and] provide microcredit opportunities for them to start small sustainable businesses. We must invest heavily in education programs that include environmental and social issues. Conservation cannot work until it is in the understanding hands of the people who live on the land. The use of GIS, GPS, and satellite imagery can help map changes in the landscape; radio collars help monitor the movement of animals; and camera traps can teach us a great deal about the diversity of mammals.

It can be argued that the social implications of climate change are often overlooked. What are some of the most pressing ones, in your view, and how should they be addressed?

There is no question that those in poverty are suffering the worst effects of climate change. When sea levels rise, causing severe flooding and erosion, or when there is prolonged drought or damage from one of the increasing number of really bad hurricanes and typhoons, higher-income families can afford to move or repair, while the lives of those without these resources are as devastated as their property. You only have to read the stories of those affected by storms and flooding in, for example, Bangladesh or Puerto Rico, or by drought in the Sahel region, or the terrible fires in the US. Climate refugees coming to Europe or North America, desperate to earn money to send money back to their families, are only too often treated with hostility. Climate change may cause conflict when it leads to food shortages and loss of livelihoods. It seems only right that wealthy industrialized countries that have contributed most to global warming should help disadvantaged communities tackle changing climates and help displaced people to find ways of making a living. We need to ensure equitable payment for goods produced by people who are forced to live day by day on the pitiful money paid for their labor, and provide microcredit opportunities to enable people to start small sustainable business and earn enough to ensure healthcare and education for their children.

Pexels / Alex Azabache
See endnotes on page 66.

People, health, and communities

The future of our planet is deeply linked to the health and well-being of its inhabitants. Our environment influences what we eat, where we live, and the air we breathe. Addressing climate change-related challenges is not only an environmental priority, it's a personal one. In this chapter, we explore how climate change is affecting our health and communities and set forth the options available for prevention, mitigation, and ongoing management of these threats to our quality of life. We see opportunities for investors in companies with exposure to green technologies, climate-related illness treatments, infrastructure and waste management, as well as private market opportunities aimed at sustainable cities.

See endnotes on page 66.

The potential effects of climate change go beyond damage to the natural environment and the exacerbation of resource scarcity. Its physical effects will impact public health and society in a number of ways that are likely to become more apparent in the coming years. Climate change has both direct and indirect effects on humans, including health and social impacts, which may be underappreciated even as societal awareness of its environmental and economic consequences has grown.

Climate change's health and social effects are most visible in cities: They are the largest single driver of carbon emissions globally, and the urban environment creates local conditions that worsen the effects of global warming and pollution, with adverse health consequences.

This chapter first addresses the human health impact of climate change, primarily driven by air pollution linked to greenhouse emissions, as well as rising urban heat. It then considers social and physical changes affecting cities as a result of climate change. The impact of environmental degradation on food supply is addressed in Chapter 4, and water safety in Chapter 5.

In the long run, we believe the most rewarding investments related to human health and environmental challenges are in solutions that help to reduce climate change at the source, such as clean fuels and more efficient buildings to reduce sources of air pollution or urban heat. Other investment options include healthcare companies with exposure to some of the consequences of climate change, including cancer and infectious disease treatment. Infrastructure and waste management companies are also relevant from the perspective of managing urban exposure to climate change, including rising sea levels.

See endnotes on page 66.

Impact on human health

The time is now

Air pollution is the fourth most common cause of death globally.[6] It leads to respiratory and cardiovascular disease and is linked to certain forms of cancer. Other effects of climate change on human health include so-called "urban heat islands," a growing problem particularly in Asian megacities, and the potential for wider spread of infectious disease by insects as temperatures rise.

Air pollution is the largest environment-linked threat to human health

Exposure to ambient (i.e. outdoor) air pollution is the largest environment-linked risk factor for premature mortality, responsible for an estimated 4.2 million deaths in 2016, according to the WHO.[7] The largest share of these deaths is caused by cardiovascular disease, with respiratory conditions and lung cancer also significant contributors to mortality. These conditions are also linked to indoor air pollution caused by heating and cooking, which account for an additional 3.8 million annual premature deaths.[8] Air pollution also has an economic impact: a 2016 study by the World Bank found that premature death due to air pollution cost the global economy USD 225 billion in lost labor income, and over USD 5 trillion in welfare losses, in 2013.[9]

The core causes of air pollution are similar to climate change: Fossil fuel combustion emits both greenhouse gases and pollutants, including the tiny particulate matter (PM2.5) that is a major cause of air pollution-linked illness.

Due to their increased population density and emissions-producing activities, cities are pollution hotspots. With ongoing urbanization, the health consequences could therefore worsen unless transport and power generation changes can reduce urban air pollution. According to the WHO, 83% of cities globally exceed its guidelines for safe concentrations of PM2.5, with the highest measured concentrations of particulate matter found in South and East Asia. Air quality in Chinese cities has been generally improving, as it is, albeit more slowly, in Europe and the US.

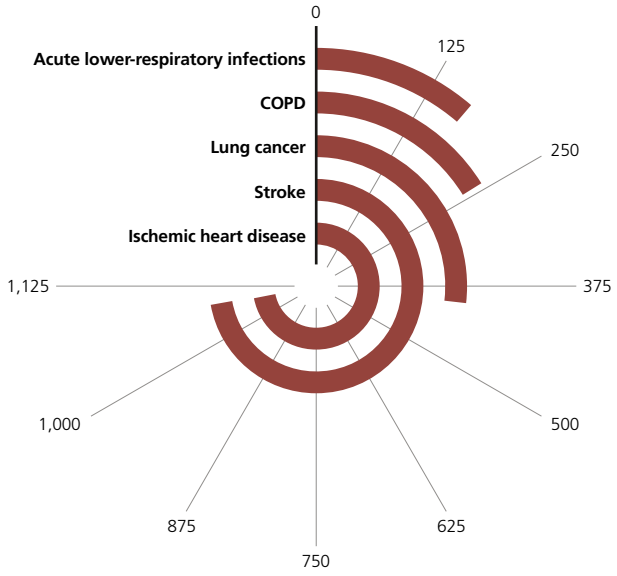
At a glance

- **The time is now**
  - Air pollution is the largest environment-linked threat to human health
  - Extreme urban heat is claiming lives and jobs
- **Where to invest**
  - Treatments for illnesses linked to climate change, including drugs and medical devices
  - Companies that effectively address the health and safety of their employees

Figure 4

Top five causes of death linked to air pollution

In thousands



Note: COPD = chronic obstructive pulmonary disease
Source: World Health Organization 2016, "Ambient Air Pollution: A global assessment of exposure and burden of disease"

See endnotes on page 66.

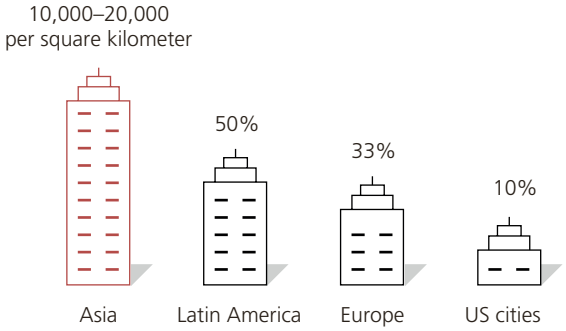
In addition, the impact of air pollution is higher for structurally disadvantaged communities. In the United States, individuals living in poverty were 35% more likely to be exposed to pollution particulates than the general population. Communities of color also bear more of the burden of air pollution. Black Americans were 54% more likely to be exposed to increased pollution, and overall people of color across races and ethnicities were 28% more likely to be exposed than white individuals.[10]

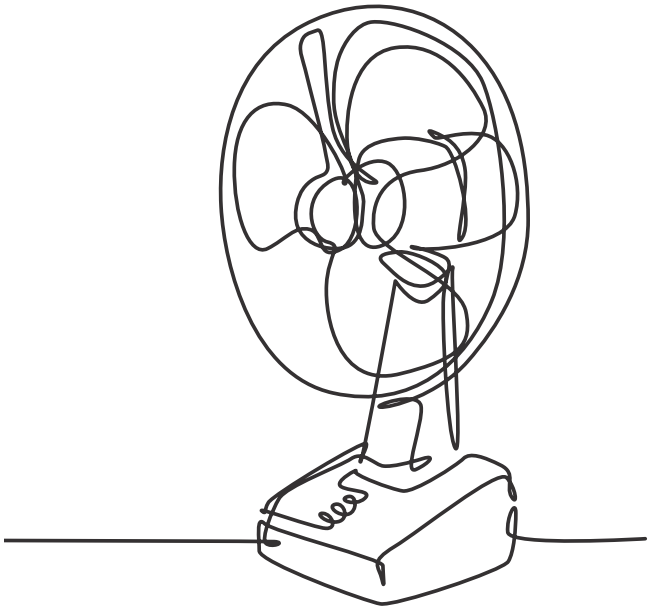
Extreme urban heat is claiming lives and jobs

In addition to air pollution, extreme air temperatures pose another major threat to human health and well-being. According to Climate Impact Lab, over the next decade, North Africa, the Middle East, and Asia will experience the highest average summer monthly temperatures, which could peak in the mid-to-upper 40s centigrade if we do not make significant progress on reducing emissions.[11] The situation is particularly concerning in urban centers and will continue to intensify as urbanization trends unfold in these emerging regions.

Relative population density

The urban heat island phenomenon results from intense human activity and energy consumption in areas of high population density





The urban heat island (UHI) phenomenon results from intense human activity and energy consumption in areas of high population density. Population density in parts of Asia averages 10,000 to 20,000 per square kilometer, double the density of Latin America, three times that of Europe, and 10 times that of many US cities. This is achieved through high-rise living, with the resultant concentrated human activity evidenced in air pollution, traffic congestion, and high electricity consumption. Thermal radiation from city infrastructure, particularly buildings and roads, can also cause temperatures to rise 10–15 degrees Celsius above air temperature.

Rising demand for air conditioning in urban heat islands substantially raises electricity demand. In high-rise cities like Hong Kong and Singapore, it explains why buildings are responsible for 90% of electricity consumption. Air-conditioning units use condensers, which vent hot air outside, raising outside temperatures particularly in the evenings. The condensers are high consumers of electricity; thus, where the local energy grids use fossil fuel generation, the combined energy demand from air conditioning units will have a large carbon footprint. This indirectly drives a vicious heat cycle.

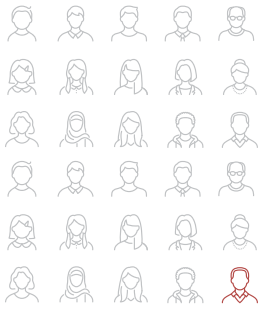
See endnotes on page 66.

Climate Impact Lab estimates that by the end of the century, extreme heat could kill 73 per 100,000 people, roughly equal to the current death rate for all infectious diseases, including tuberculosis, HIV/AIDS, malaria, dengue, yellow fever, and diseases transmitted by ticks, mosquitoes, and parasites.[12] Heat stress is particularly dangerous to those suffering from cardiovascular and respiratory ailments and tends to disproportionately affect the very young and those over 65. It can also lengthen periods of disease transmission and compromise fresh water supplies. This impact could materialize across the world. A study of 209 US cities projected that by 2030 there could be an increase of 8,000 to nearly 12,000 premature deaths attributable to temperature increases.[13]

There are economic consequences to extreme urban heat as well. The immediate economic impact of heat stress tends to be on labor productivity, particularly in those industries reliant on manual or outdoor labor. According to the International Labor Organization,[14] Asia and the Pacific are regions that stand to lose the most from heat stress, at 3.1% of the work force by 2030, equivalent to around 62 million full-time jobs.

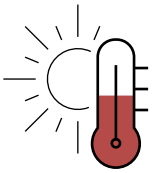
Rising temperatures from extreme heat events increase evaporation, drying soils and increasing the risks of droughts which may have devastating human health and economic impacts,

Heat stress on labor productivity
Asia and the Pacific stand to lose 62 million full-time jobs by 2030 from heat stress



–3.1%
of the workforce by 2030

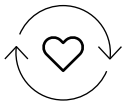
Heat stress on lives
By the end of the century, extreme heat could result in the same death rate as all infectious diseases



Extreme heat could kill
73 per 100,000 people
by the end of the century

ranging from food instability due to supply chain disruption to the increased risk of infectious diseases and mental health issues in affected communities. The US state of California suffered a four-year drought between 2012 and 2016, the most severe in the state's history since 1850, with 63 emergency proclamations issued by the state and local level governments. A study of two California counties during that period found increased instances of chronic disease and worsening mental health in these communities.[15] Rising heat waves and droughts create conditions for wildfires. Wildfires are a naturally occurring phenomenon and can be beneficial to ecosystems. However, in some parts of the world, they have become increasingly larger. For instance, in the Unites States, the number of acres burned each year since 1991 has been increasing according to the US National Interagency Fire Center. Seven of the 10 largest, most destructive wildfires in California, a highly populated state, have happened between 2015 and 2020, leading to displacement, property destruction, increased respiratory illness, and loss of life. Australia is another region under threat. The bushfires at the end of 2019 and early 2020 were the most catastrophic on record in the country, with 19 million hectares burnt, 1.25 billion animals killed, and 33 human lives and 3,904 homes lost, according to WWF Australia.[16]

See endnotes on page 66.



Links between air pollution and health

Air pollution has been known for many years to have adverse effects on human health. One well-documented example is the famous London smog of 1952, which caused death rates in the city to spike, briefly reaching levels last seen at the height of the 1918–19 flu pandemic. It has since been shown that air pollution exacerbates existing lung disease and may also cause new chronic conditions including respiratory and cardiovascular diseases. It leads to decreased exercise capacity and premature mortality, and emerging research suggests it affects individuals' physical and mental productivity.

Air pollution is a complex and varying mixture of different pollutants. The precise mechanisms by which it causes illness are unclear but are thought to include inflammation that reduces lung function. One hypothesized link to cardiovascular disease is via a chronic inflammatory state that may contribute to the development of atherosclerosis (the buildup of fat and cholesterol in blood vessels). From a health perspective, particulates are the most concerning component of air pollution.

- **Particulates** are airborne solid and liquid particles such as dust, pollens, soot, and leftovers from combustion. The most hazardous are fine particles below 2.5 micrometers in diameter (PM2.5) that can penetrate far into the lungs due to their small size and are linked to increased risk of heart disease, lung cancer, and asthma. A meta-analysis of studies from 1950–07 published in 2009 found a clear correlation between particulate matter and mortality, independent of age, gender, and geographical region. The Lancet estimates that 390,000 deaths in 2018 were caused by particulate pollution from coal-fired power generation alone.

- **Ozone (O_3)** is also of significant concern. It is a byproduct of fossil fuel combustion formed when volatile organic compounds (VOCs) react with nitrogen oxides in the presence of sunlight. Ground level ozone causes lung inflammation and respiratory discomfort, exacerbates existing bronchitis and asthma, and, with prolonged exposure, may lead to chronic lung disease.

- **Other key airborne pollutants** include sulfur dioxide, nitrogen dioxide, and carbon monoxide. They are typically generated by motor vehicles (internal combustion engines, particularly diesel fuel), energy generation, and industrial processes. Direct emissions from industrial facilities may also contribute to worsening air quality. Moreover, not only are many of the causes of climate change also responsible for air pollution, but global warming may in fact worsen its effects, since ozone has been found to be more damaging to health at higher temperatures.

See endnotes on page 66.

Solutions for the future

Addressing the human health impacts of climate change is a complex challenge that will require a multi-pronged approach. The solution starts with attacking the root causes of climate change. Next, a combination of medical devices and pharmaceutical drugs can help to treat air pollution-linked illnesses. Finally, energy efficiency technologies and infrastructure upgrades can aid in reducing urban temperatures. We see investment opportunities across all three of these areas.

Mitigation strategies are the first step

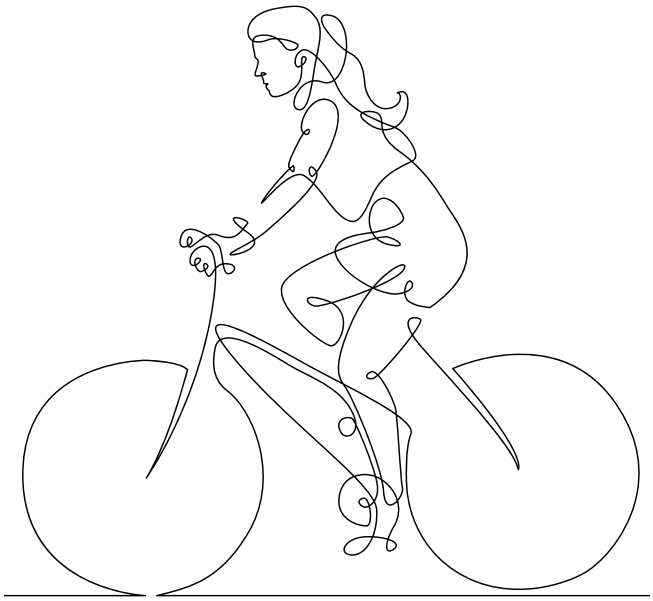
Climate change mitigation efforts should have a corresponding effect in reducing the negative impact of climate change on human health. Since power generation is the largest single contributor to air pollution, transitioning to a more sustainable energy mix, as outlined in Chapter 3, will reduce new sources of air pollution in the future, as will shifting toward more sustainable transportation infrastructure.

While these steps may help slow the growth of mortality and morbidity linked to air pollution, it may already be too late to prevent its effects over the coming years, thanks to the accumulated effect of existing pollution. For example, the International Energy Agency (IEA) estimates that in a "business as usual" scenario, premature deaths due to outdoor air pollution could rise 17% by 2030, compared to 2019.[17] A more optimistic scenario, where global emissions peak in 2019 thanks to rapid investment in clean energy technologies, would still see annual deaths essentially flat over the period (although the outlook for indoor pollution is more optimistic).

Treating climate-related health conditions can save and improve lives

Cardiovascular and respiratory disease and lung cancer are the main health conditions linked to ambient air pollution. Collectively, we estimate the size of these markets at close to USD 100 billion. We note that each condition has multiple causes beyond air pollution, including "lifestyle" factors such as sedentary lifestyle or smoking.

- **Cardiovascular disease** is the most common cause of air pollution-linked mortality, primarily stroke and ischemic heart disease. Treatments for these conditions range from drugs to reduce the risk of adverse cardiovascular events, prevent blood clots, and manage cholesterol, to implantable medical devices that can help control heart rhythms. Cardiovascular drugs currently represent around 5% of the global pharma market, with low-single-digit volume growth rates in aggregate, but are dominated by generics after several multi-blockbuster products lost patent protection in recent decades. The branded component of the market, largely anticoagulants used to manage the risk of blood clots, is worth about USD 20 billion, we estimate. For medical devices used to treat cardiovascular conditions, we estimate the global market is around USD 40 billion.



- **Respiratory disease and allergies** are also widely linked to air pollution, primarily lower respiratory tract infections and chronic obstructive pulmonary disease (COPD). Particulates can exacerbate existing lung conditions such as asthma, leading to hospital visits and higher healthcare costs. They may also contribute to allergies, which, while not necessarily driving mortality, can be a significant cause of morbidity for patients. Treatment for respiratory conditions is mostly drug-based. We estimate that the branded respiratory drug market is worth around USD 18 billion, with growth likely to remain in the low single-digits.

- **Cancer** is primarily a disease of aging. It results from accumulated mutations of cells, which are more likely to occur as we age. But environmental factors can also lead to cancerous mutations within cells, and particulate matter has been linked to higher incidences of several cancer types, notably lung cancer. We estimate that ambient air pollution is responsible for around 20% of global lung cancer deaths, based on data from WHO and the International Agency for Research on Cancer.

See endnotes on page 66.

Reducing the energy intensity of cities can bring down the heat

Addressing the social and economic impact of urban heat islands starts with mitigation at the city planning and building code level. One example is optimizing architectural design methods, including sky view, wind speed, tree coverage, water surface coverage, and grass surface coverage to facilitate more wind penetration and greenery.

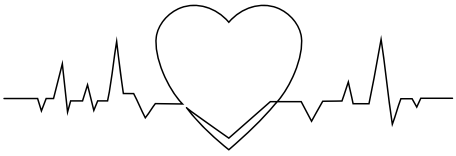
Pursuing energy efficiency to reduce demand surges on the electricity grid is another potential remedy. This entails the use of spot electricity pricing to encourage nighttime usage of certain household appliances. Consumer behavior with regards to electricity consumption can also be altered through the use of smart meters. Education on heat control measures, including drawing blinds during the day, can also contribute to greater energy efficiency.

Finally, there are ways to manage the effects of extreme temperatures on human life. Examples include heat preparedness planning, identifying vulnerable populations, and providing cooling centers.

Where to invest

First, investors can focus on solutions providers across the dimensions we have discussed. With regard to climate change mitigation, we see an opportunity to invest in companies with exposure to green technologies ("greentech"), such as renewable energy and smart infrastructure and mobility. Turning to the treatment of climate-related illnesses, we see attractive long-term growth prospects in the areas of oncology, healthtech, and respiratory and cardiac drugs and medical devices. Finally, we believe that global engineering and architectural companies, as well as industrial firms, that devise innovative solutions to combat urban heat are well positioned for the future. We would note that a number of the firms that specialize in green design are privately owned.

Second, investors can pursue ESG approaches that consider how companies' operations impact human health, especially in industries that emit high levels of greenhouse gas. Companies that prioritize social issues like public health, workplace safety, and equality should enjoy benefits such as a healthier, more stable workforce over the long run.



SDG 3: Good health and well-being
Ensure healthy lives and promote well-being for all at all ages

Source: https://sdgs.un.org

See endnotes on page 66.

How climate change could impact the spread of infectious disease

The COVID-19 pandemic has alerted the world to the danger of new zoonotic viruses and perhaps raised the long-term demand for identifying and treating respiratory infections. But another source of infectious disease burden is the wider prevalence of diseases already known to infect humans. Warmer temperatures allow insects and other disease vectors to spread across a wider geographical range and altitude, and may also increase the length of time during which they can transmit disease to humans. While the primary concern is mosquitoes, warmer temperatures can also increase disease transmission from non-insect sources, including waterborne bacteria such as cholera, by lengthening the time during which conditions are amenable to transmission.

One study[18] estimated that 383 million people will be exposed to mosquito-borne diseases for the first time in an immediate-mitigation climate scenario, while a more realistic scenario, in which GHG emissions peak around 2040, would see this number exceed 600 million. Temperate regions such as Europe are most at risk, while in some scenarios parts of Africa and Asia may in fact see modest net reductions of exposed populations.

Historically, developed economies have controlled insect-borne disease by a variety of means including pesticide application and reducing mosquitoes' breeding grounds. For example, the US eliminated domestic malaria in the 1950s, and Singapore was declared malaria-free by the WHO in 1982. By contrast, the global incidence of dengue fever has risen over the past 30 years, fueled by a warmer, wetter climate and the spread of the urban environments in which the aedes aegypti mosquito thrives. According to The Lancet, nine of the 10 most suitable years for dengue transmission have occurred since 2000.

Investment opportunities related to infectious disease fall into three main categories:

- **Diagnosis.** Rapid identification of infections is important to understanding and halting the spread of disease, and wider prevalence of infectious diseases in developed markets could be expected to increase demand for molecular diagnostic testing. But we would not expect a rapid windfall of diagnostic capital equipment as seen in the current pandemic; in fact, following rapid capacity expansion in 2020, there is a risk of oversupply in the medium term. The global diagnostics market is expected to grow by high-single-digit rates over the coming years.
- **Prevention**. The rapid development of vaccines against SARS-Cov-2 has demonstrated the utility of innovative vaccine platforms using techniques such as mRNA and adenovirus. With proof of concept established for these technologies, they could be rapidly deployed against future viral infections, although we would expect a slower development process in the absence of the urgent need caused by a global pandemic. An alternative approach is attempting to control the mosquito population by genetic engineering or gene editing. This has been shown to reduce wild mosquito populations in limited trials, but is a controversial approach and has not been attempted at broad scale yet.
- **Treatment**. Infectious diseases are treated with antivirals and antibiotics. As a group, anti-infective drugs make up around 10% of the global pharma market but have a below-market growth rate, partly due to the declining use of hepatitis C drugs, which make up a significant proportion of antiviral sales. Prior to COVID-19, investment in infectious disease treatment, and antibacterials in particular, lagged relative to global drug spending due to the perverse incentives caused by antimicrobial resistance (AMR). To minimize the risk of AMR, it is likely that newly developed antibacterial drugs would be held in reserve, rather than used widely, which reduces the incentive to develop them. According to one estimate, however, deaths attributable to resistant bacterial infections could reach 10 million by 2050, approximately a tenfold increase from today's levels. New financial models for antibacterial drug development are urgently needed, in our view.

See endnotes on page 66.

External view

Dr. Kamran Khan

Founder and CEO of BlueDot, and UBS Global Visionary

Dr. Khan, what have we learned about human resilience to infectious diseases in recent years?
What we've learned is that true resilience requires each of us to be empowered to do our part. Governments alone won't be able to tackle the global threat of infectious diseases, nor will industry, civil society, or the healthcare sector in isolation. We've also learned that as a global community, we are only as strong as our weakest link, which means we need to address deep inequalities locally and globally that infectious diseases can readily exploit.

How has climate change factored into the way we think about preventing and treating such diseases, especially in the most vulnerable regions?
Climate change is transforming the global landscape of infectious diseases—this is especially true for diseases spread by mosquitoes, ticks, and other insects. With changing climatic conditions, insects are able to thrive in new areas of the world, becoming vectors for dangerous diseases like dengue, chikungunya, Zika, Lyme, and others. So, while we may think of climate change as an ecological issue, it's important to recognize that it is also a key driver of infectious disease outbreaks.

How can technology help deal with these impacts? Is there space for more collaboration between technology providers and pharmaceutical companies in developing new solutions?
Big data, artificial intelligence, and digital technologies are already helping governments respond to this pandemic and prepare for the inevitable threats we will face in the future. The same innovations that generate real-time global epidemic intelligence can help empower the biotech and pharmaceutical sectors to direct their life-saving solutions—diagnostics, therapeutics, and vaccines—to areas of the world that will need them most.

What is your view on the outlook for dealing with the next pandemic? Are we better prepared?
We've learned a lot from this pandemic—the hard way. We all know the famous aphorism that an ounce of prevention is worth a pound of cure. The outstanding question is whether the world will continue to invest in strengthening readiness and building resilience once this pandemic is over. But with all the innovations that have come out of this pandemic, I'm very optimistic that we'll be better prepared for the next one.

This interview contains views which originate from outside Chief Investment Office Global Wealth Management (CIO GWM). It is therefore possible that the interview does not fully reflect the views of CIO GWM.

Impact on our communities

The time is now

Climate change not only impacts human health and mortality; it also influences the sustainability of our communities. These adverse effects are disproportionately felt in parts of the emerging world, leading to displacement of low-income populations, and, in the most extreme cases, have put some areas at risk of becoming uninhabitable. Beyond the human toll, there is a large economic cost associated with these trends. We see an opportunity to invest in preserving and fortifying communities in the face of extreme weather patterns.

Flooding and sinking cities remain a threat
One of the consequences of climate change is rising sea levels. Climate models forecast global warming will raise water levels anywhere between 0.35 and 0.74 meters this century, with a 0.3% to 9% impact on global GDP.[19]

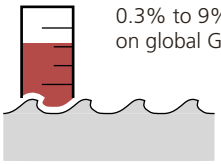
Asia and Africa will bear the biggest economic and social brunt of rising sea levels due to these regions' unique urban geography. Asia is a good example. The region has 21 of the world's 33 megacities (cities with population over 10 million), nearly all of which are coastal. Most of the region's economic activity has grown around 10 river basins, which represent USD 4.3 trillion in GDP. The Asian Development Bank estimates that 16% of annual infrastructure spending—around USD 272 billion per year—is needed to address climate adaption and mitigation measures. It further estimates that the annual cost of natural disasters in Asia Pacific rose to USD 76 billion between 2007 and 2016, double that of the previous decade.[20]

Similar to Asia, Latin America's population and economic activity are heavily concentrated in urban areas, which present a number sustainability challenges. Additionally, long coasts—considered one of the region's attractive features—present risks to the countries' populations. For example, of the six megacities in the region, four are coastal and therefore exposed to rising sea levels. Rising sea levels brought on by climate change lead to flooding, reduced effectiveness of beaches as buffers against coastal erosion, reduced tourism, and tidal changes, among other things.

At a glance

- **The time is now**
  - Flooding and sinking cities remain a threat
  - Environmental migration as a major consequence
- **Where to invest**
  - Urban planning solutions
  - Smart cities technologies
  - Companies that effectively address their employees' working conditions and their exposure to physical climate risks

- **Water levels**
  Climate models forecast global warming will raise water levels anywhere between 0.35 and 0.74 meters this century



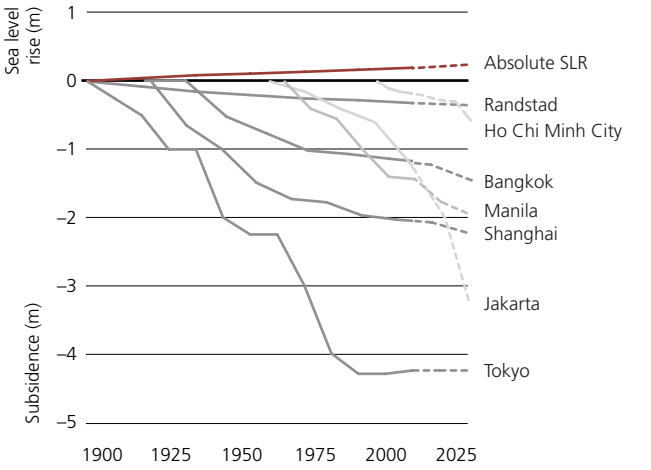
0.3% to 9% impact on global GDP

See endnotes on page 66.

The coastal areas of the United States will also be impacted. Although they account for less than 10% of the total landmass, the country's coasts are home to 127 million people, or about 40% of the population, and serve as economic engines for key industries. The concentration around the coasts makes the US highly vulnerable to the same threats from sea level rises as other regions: flooding, erosion, erratic rainfall patterns, and others. According to the 2018 US National Climate Assessment (NCA), more than 60,000 miles of US infrastructure (roads, bridges, etc.) are located in coastal floodplains and are considered high-risk. In addition to infrastructure, real estate value is at risk, and so is human health. According to the NCA, communities that are socially or economically marginalized are at higher risk from sea-level rises. The impacts vary by community, ranging from the elderly in Florida to subsistence-fishing communities in Alaska.[21] Multiple studies on the impact of Superstorm Sandy, a tropic storm that flooded nearly 20% of New York City in 2012, have found that the flood had a disproportionate negative impact on nonwhite Hispanic and Black communities who had a higher need for medical services, and faced decreasing property values, increasing insurance premiums, and longer rebuilding periods.

Figure 5

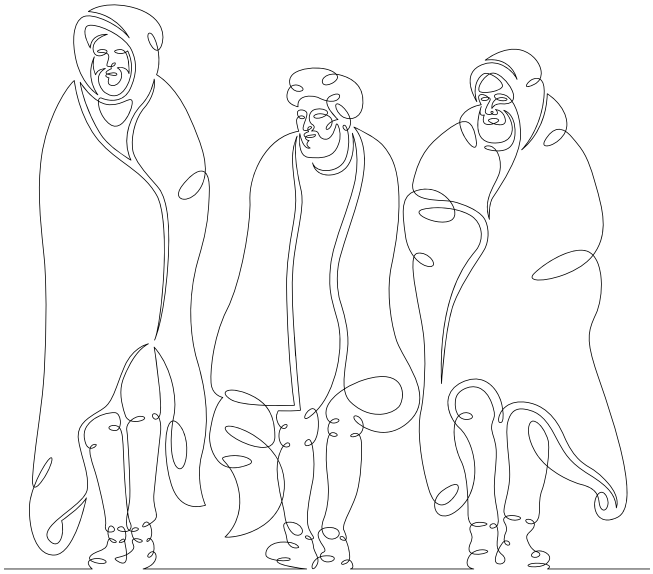
Rising global sea levels



Source: International Association of Hydrological Sciences, 2015

Aside from the rising sea levels, which take their toll on many of the world's low-lying developing regions, some of the world's richest cities—from New York to Houston, from Venice to Rotterdam—are facing another major challenge exacerbated by climate change: They are sinking, often 10 times faster than sea levels are rising. Not all of the subsidence problems of the world's largest cities are of a geological nature. In the developed world, cities like Houston and New Orleans are sinking due to excessive industrial groundwater use. In some cities, subsidence has lowered groundwater levels by up to 3 meters per year, with drainage of weighty high-rise foundations or subway tunnels and other underground structures exacerbating subsistence issues. Meanwhile, in the emerging world, excessive water pumping and deep well exploitation due to a lack of fresh water supply are adding to subsidence in cities like Jakarta and Bangkok. Jakarta, home to 30 million residents in its greater city limits, is by many accounts considered to be the world's fastest-sinking city. Estimates vary by area, but the city is giving ground by 6–10 inches a year, with almost half the city already below sea level and potentially entirely underwater by 2050.[22] The economic damage from sinking cities derives from rising incidents of flooding, damage to structures, and high maintenance costs for preventive infrastructure, as well as production outages and loss of real estate value. The cost of sinking cities in countries like China and the Netherlands has been estimated at USD 1.5 billion and EUR 3.5 billion per year, respectively.[23]

See endnotes on page 66.



Environmental migration as a major consequence

Human settlements most exposed to extreme weather events including flooding, cyclones, and melting glaciers tend to be concentrated along the long coastlines of Asia and South America within the tropical latitudes. Because these regions' economies are often largely dependent on agriculture, the ever-constant cycles of damage to crops and property make them among the poorest regions of the world. There is clear evidence that the damage from the frequency of extreme weather appears to rise. According to Germanwatch's Global Climate Risk Index 2019, between 1998 and 2018, Puerto Rico, Myanmar, Haiti, the Philippines, Pakistan, Vietnam, Bangladesh, Thailand, Nepal, and Dominica constituted the top 10 regions globally most impacted by climate change, with net losses per unit of GDP ranging from 0.4% to 0.87%. In addition to these areas, we would also note that parts of Latin America are facing similarly acute challenges due to changing weather patterns.

This frequency of extreme weather events has led to large-scale population displacements in impacted rural and urban settlements, termed "environmental migration." Of the 68.5 million people forcibly displaced globally, 22.5 million lost their homes due to "unforeseen" weather events in 2018, with the World Bank estimating this will rise to 143 million more by 2050.[24] Environmental migration has led to the creation of major climate-migrant corridors over the last two decades, most evident between Bangladesh and India; Afghanistan and Pakistan; India and Pakistan; and Nepal and India. They have also spilled over to Southeast Asia via Myanmar.

The situation is intensifying in Latin America, too. The major cities of the region have already started to see migration out to their surrounding areas, and rising sea levels and more extreme weather could speed up the trend. In Brazil and Mexico, roughly 2 million and 500,000 people, respectively, are susceptible to a one-meter rise in sea levels, according to the Economic Commission for Latin America and the Caribbean. Climate change has ramifications for the rural segment of the economy that makes up a quarter of the region's exports as well. Deforestation is perhaps one of the most relevant issues from a global scale, as the Amazon rainforest is considered to be the lungs of the earth and provides an effective way to capture carbon emissions (see box). Furthermore, with roughly one-fifth of the region's population working in the agricultural industry, livelihoods may be at risk if severe weather events and droughts occur on a more regular basis. Rising temperatures also mean some farmers will need to adapt by either changing the crops they grow or relocating. This is already happening with coffee farmers who are seeking land at higher altitudes to offset a rise in temperatures.

Climate migrant flows produce multiple sustainability issues ranging from the economic to the social and geopolitical due to their cross-border nature. Migration to less developed areas, especially if it is sudden, brings challenges to governments. They must address the expansion of public services, interruptions to land use, and damages to the ecosystem. If those migrating have lower income, which is likely in developing nations, they will probably have few savings and limited access to healthcare and other services, making them vulnerable to unforeseen climate-related emergencies like flooding and severe weather.

For example, 3.2 million Bangladeshi migrants are present in India, with a future estimated 15 million more, driven by damage to the Bangladeshi coastline.[25] These migrant flows have created ethnic tensions in India and triggered armed conflict in Myanmar. Women and children have also become a particularly high-risk group due to large-scale trafficking across migrant corridor borders. Addressing the climate migrant dilemma on a domestic or multilateral basis is complicated by the fact that "environmental migrants," as the United Nations High Commissioner for Refugees calls them, have no official refugee status.

See endnotes on page 66.

Solutions for the future

There is a broad range of approaches to addressing urban subsistence issues. Mitigation measures include construction codes requiring the use of lighter building materials for structures, or more flexible materials for exposed infrastructure such as piping. A solution tackling the issue at its roots is a focus on water treatment; i.e., if wastewater gets recycled, the need for groundwater wells reduces. The same is true if water availability on the surface is clean enough for consumption. Some cities have also had success reinjecting water into the ground layers. Urban planning will need to play a critical role as cities expand. Avoiding flood-prone or water-absorbing peatland areas helps; in fact, some cities now take to re-expanding these areas. Heavy water users, industrial or otherwise, can be directed to avoid areas that already critically lack groundwater or tax or restrict groundwater use. The good news is that Bangkok, Shanghai, and Tokyo have been able to slow the sinking this way, but halting the sinking can take up to 10 years.[26] Flood management provides additional relief. "Sponge city" engineering design concepts have been adopted in China's Greater Bay Area. The 60,000-square-meter underground storage water facility under Hong Kong's Happy Valley Recreation Ground is one example. Thailand has built green areas in the center of the city, one of which, the CU Centenary Park, can absorb 1 million gallons of flood water.[27] Redirecting rivers away from overloaded low points is also a good starting point. Proper design and maintenance of drainage systems, as well as putting into place barrier structures, aid the efforts; the Giant Sea Wall of Jakarta is one prominent example.

The importance of national policymaking to strengthen resilience to climate-related hazards, i.e., mitigation, and incorporating climate change as part of the solution cannot be emphasized enough. Such policies also include raising education and awareness of climate change issues particularly for target rural communities.

SDG 11: Sustainable cities and communities
Make cities and human settlements inclusive, safe, resilient, and sustainable

Source: https://sdgs.un.org

SDG 10: Reduced inequalities
Reduce inequality within and among countries

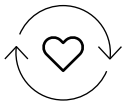
Source: https://sdgs.un.org

Where to invest

We see opportunities in publicly listed infrastructure companies that offer services from wastewater plant construction to dredging and implementing preventive facilities. For South Asia in particular, we see concrete solutions in building climate-smart infrastructure, which is resilient to extreme weather and climate change, and reduces emissions through the use of renewable energy and energy efficiency technologies. Other options include select green bonds, sustainable municipal bonds, and regional banks with exposure to infrastructure. There are also opportunities within the agricultural sector, including agricultural technologies and machinery companies that help farmers improve yields in afflicted communities. Within private market investments, companies that provide solutions to effective climate-resilient urban planning and affordable housing would be well positioned to capture the growing need to find solutions for displaced communities.

ESG-focused investors could select companies that actively address working conditions, health, and equality among their employees and within their supply chains. In addition, investors should consider companies that actively address the physical risk of climate change across their operations by developing and implementing effective climate change strategies and investing in mitigation.

See endnotes on page 66.



Spotlight on the Amazon rainforest

As we will discuss in Chapter 4, climate change and the preservation of forests are inextricably linked. The International Panel on Climate Change (IPCC) estimates that ending deforestation and allowing forests to recover could reduce current annual global emissions by 24–30%. In fact, by slowing deforestation in the Amazon by 80% for the decade beginning in 2004, Brazil was the single-largest contributing country in decreasing emissions around the world, according to the Center for Global Development. And doing so was relatively inexpensive, costing only a few dollars per ton of avoided emissions. On the other end, estimates for losing roughly 300 million hectares of forests in the next 35 years will contribute 169 billion tons of carbon dioxide, roughly one-third of the global emissions budget to maintain global warming to under 2 degrees Celsius.

Most of the focus on deforestation has been placed on the 60% of the Amazon rainforest that lies within Brazilian borders. Over the last two years, the rate of deforestation has nearly doubled compared to the previous five years, according to the Amazon Environmental Research Institute (IPAM). Researchers at IPAM attribute this trend mainly to a rise in forest fires by land grabbers as enforcement actions have declined under the current Brazilian government. Brazil has regulations in place whereby a portion of a private property in the Amazon must be set aside for preservation, and land owners can self-claim their property boundaries and the government would certify them. Unfortunately, the certification often doesn't occur, which allows ill-intentioned actors to claim public lands and use them as they wish. Closer monitoring of property in the Amazon is one step the Brazilian government could take and, according to IPAM, would have prevented nearly one-third of the fires in 2019 and one-half of the fires in the first quarter of 2020, when the latest data is available.

See endnotes on page 66.

"We all have to now imagine this future that we have to hurry towards, because it is going to be a better future. It's going to be a much healthier future. It's going to be a future that is all about clean energy and living a sustainable life."

Mary Robinson, former President of Ireland and Chair of The Elders*

Unsplash / Gonz DDL

See endnotes on page 66.

Energy

Energy-related emissions account for over two-thirds of global greenhouse gas emissions (GHG), highlighting the need to end our reliance on fossil fuels. But successful transition away from GHG-emitting energy must also safeguard the world's energy security. Reliable and affordable energy supplies are needed for ongoing economic growth and development to serve the needs of a growing global population, and to provide relief for the large portion of the global population that currently lacks access to energy for life's most basic needs such as lighting and cooking. In this chapter, we discuss the opportunities and solutions for a sustainable energy transition.

See endnotes on page 66.

At a glance

- **The time is now**
  - Balance between energy security and long-term environmental impact is needed
  - Increasing pressure on rapid capacity growth in a short period of time
  - Sustainability of new technologies and infrastructure needs to be considered
  - Role of government and policy is key
- **Where to invest**
  - Renewable energy generation
  - Electric transport, fuel cells, batteries
  - Alternative fuels: hydrogen, biofuels, natural gas, synthetic fuels
  - Carbon capture technologies
  - Energy efficiency solutions
  - Companies that manage their carbon footprint effectively

The time is now

A complete decarbonization and transition to clean fuels is an enormous task. History has shown that scaling up supplies of any energy resource takes decades, and this is why it is important to begin the process now.

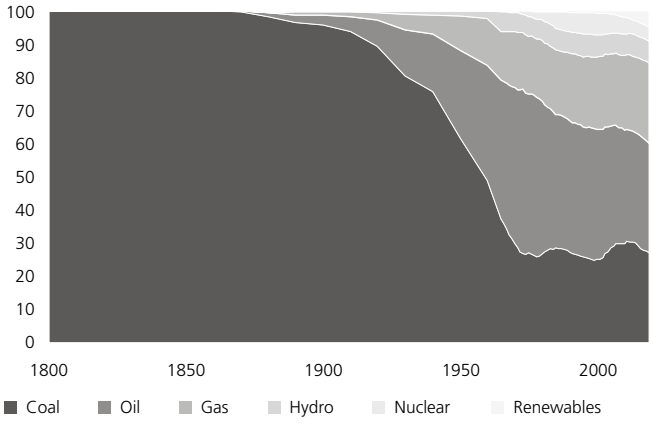
For nearly all of the past century—before, during, and after the Industrial Revolution—the most affordable and reliable energy resources have been fossil fuels. For the past several decades, demand for these fuels has risen year after year, and emissions of carbon dioxide (CO_2) and other toxins have increased substantially. And emissions could continue to rise before they fall due to the increasing concentration of greenhouse gases, including CO_2, methane (CH_4), nitrous oxide (N_2O), ozone (O_3), water vapor, and particulates in the atmosphere.

Balancing environmental costs with the reality of meeting the needs associated with urbanization and industrialization requires long-term planning. This applies not only to energy production and transition, but also to innovative and supportive city, state, and national programs and policy, including a regulatory framework that effectively imposes a cost on CO_2.

Figure 6

Primary energy consumption by fuel

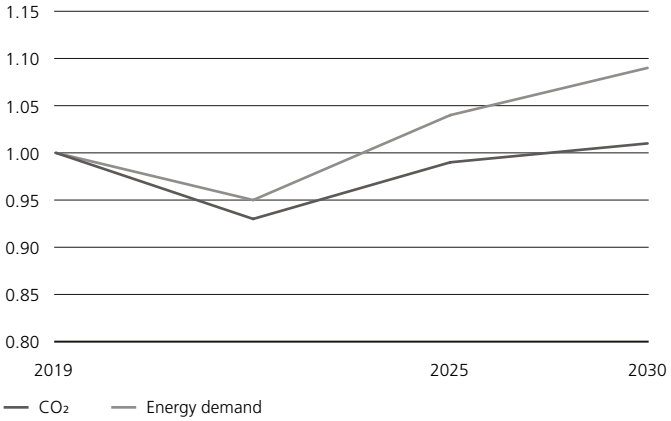
In share of total, in %



Source: BP Statistical Review of World Energy 2020, Morgan Stanley, UBS

Figure 7

Global energy demand and CO_2 emissions



Note: A dip beginning in 2020 reflects COVID-induced lockdowns. Demand for all energy resources fell, except for renewables. Index (2019 = 1.0)
Source: BP Statistical Review of World Energy 2020, International Energy Agency (2020), World Energy Outlook 2020, IEA, Paris, UBS

See endnotes on page 66.

Energy is essential, but energy development is costly, highly technical in nature, and requires constant diligence to guard public safety and the environment. So for good reason, it is a topic of social and cultural interest and at times consternation. Energy producers, service providers, supply distributors and marketers, and end-users all have unique and often conflicting objectives, and there will always be debate. However, the shared priority among all energy stakeholders is long-term energy security through clean, steady, reliable, and affordable energy supplies.

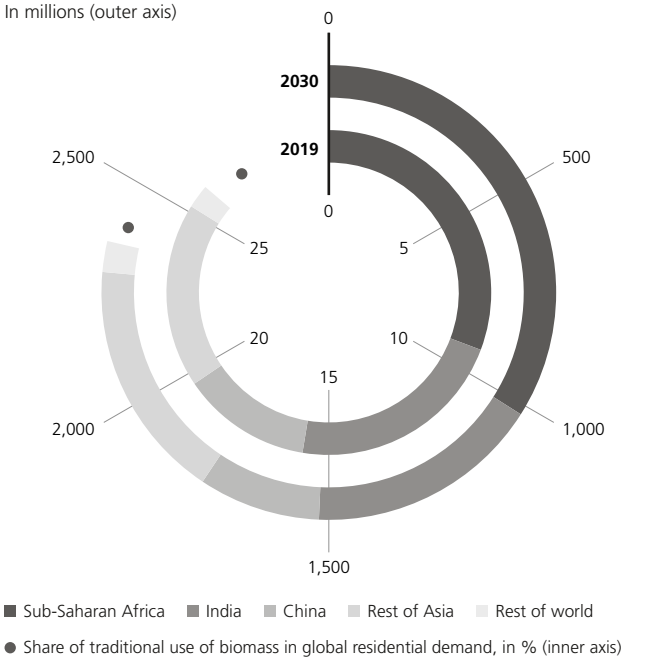
Balance between energy security and long-term environmental impact is needed

Energy supports the world's economic growth, and access to reliable energy is a key determinant of the quality of living standards, which remains elusive to significant parts of the world. Without additional policy measures and support, 2.4 billion people are projected to remain without access to clean cooking in 2030.[28] Cleaner and more sustainable energy resources will be key to meeting sustained demand growth, but may not be sufficient due to costs, logistics, and reliability issues. Even in the developed world, maintaining adequate, affordable, and reliable energy supply requires careful management, likely a phasing-in rather than a full replacement, which means slower progress in emissions reductions.

New energy solutions may carry different environmental impacts and risks and should undergo full life-cycle impact analysis—from the environmental impact of mining, to the harvest of rare earth materials, to land use and water supply—to ensure alignment with long-term climate goals as well as investment viability. For example, while biofuels offer the benefit of reduced CO_2 emissions when burned, the US Environmental Protection Agency's 2018 impact study noted potential drawbacks, including changes to land use patterns that may increase GHG emissions; pressure on water resources and water pollution; increased emissions from agricultural equipment used for growing and harvesting feedstock; and decreased food supply that in turn boosts food prices. Depending on the feedstock and production process and the time horizon of the analysis, biofuels can have a greater detrimental effect on the environment than fossil fuels.

Figure 8

Population without access to clean cooking

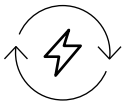


Source: International Energy Agency (2020), World Energy Outlook 2020, IEA, Paris

Increasing pressure on rapid capacity growth in a short period of time

Managing supply during the transition phase could be challenging given the quantities of new resources and the capital-intensive nature of the business. And the required level of planning and permitting can extend the development time to several years. In addition, reliance on scarce resources should also be considered. Some components used in the production of energy solutions contain a variety of natural resources such as lithium, cobalt, copper, and nickel. Not only is mining energy-intensive, but supply fluctuations are also likely to occur; and over time, cost of supply could rise as some materials grow in scarcity.

See endnotes on page 66.



A green wave is forming on the US policy front

Joe Biden's new term as US president, along with the narrow Democratic majority in the Senate and the House, marks a shift to a more climate-friendly regulatory environment in the US, one that is likely to promote increased spending on green initiatives. President Biden has made addressing climate change a top priority of his administration. He has used his executive powers to rejoin the Paris climate accord, halt new oil and gas activity on federal lands, and order the electrification of the federal government's vehicle fleet. In addition, he is taking a "whole-of-government" approach to addressing the climate crisis, appointing leaders with climate experience and expertise to key government positions.

The first installment of the recently announced infrastructure plan, titled the "American Jobs Plan," includes a number of favorable policies to encourage investment in green infrastructure projects. The proposal includes USD 620 billion for transportation, USD 650 billion for clean water and broadband initiatives, and USD 180 billion for research and development, as well as other sustainability related incentives that look set to accelerate the transition to a net zero economy. In the realm of transportation, USD 174 billion in spending is aimed at electric vehicles. Clean energy should also benefit from the extension of investment and production tax credits. Still, with only a slim Democratic majority in Congress, uncertainty remains around what the final package will entail. Regardless, we view the shift in US policy, combined with the already strong momentum we see in other major economies, such as Europe and China, as a key driver of our favorable view on green technologies.

Suitability of new technologies and infrastructure needs to be considered

For now, any given renewable energy resource is not necessarily suitable for all energy use. Electricity produced from carbon-free solar and wind power, for example, is not optimal for powering airplanes, which still rely on oil, the most dominant of all energy resources. Over time, more technologies will emerge to either replace oil (biofuels, natural gas, hydrogen, synthetic fuels), combustion engines (electric batteries, fuel cells), or even transportation methods. Adaptation would be specific to different uses across different sectors.

Role of government and policy is key

The future of energy and its impact on earth is a generational consideration, one that extends beyond borders, politics, and economic cycles. As such, the response must be global and multilateral. But most of the commitments made are high-level, with inconsistencies in implementation across regions, and even within national political regimes or economic cycles.

While rising popular support among consumers and investors should improve alignment in the years ahead, it remains crucial to ensure a coherent national policy, from energy management regulations to long-term climate-focused directives. It will be important to guard against mandates that lock in existing technologies and disincentivize innovation and technical advancement.

Apart from a national energy management policy, related supporting policies would also have significant implications on energy usage in the future. One such example is the attempt to impose a price on carbon, which should encourage a more complete alignment of environmental and financial costs. This has already been a decades-long effort, and according to the World Bank, 46 countries covering over 20% of GHG emissions currently put a price on CO_2 emissions. That said, liquidity, pricing, and credit mechanisms differ, and the average carbon price lags behind the estimated fair value. The introduction of accompanying carbon credits is hoped to alleviate the near-term costs for clean energy technologies, thereby encouraging uptake. We may also see scale inflection with the 2020 launch of CORSIA, a unified aviation carbon credit system, and with the national rollout of China's domestic carbon trading system, which is already forecasted to become one of the world's largest in 2021 despite its early phase.

See endnotes on page 66.

Solutions for the future

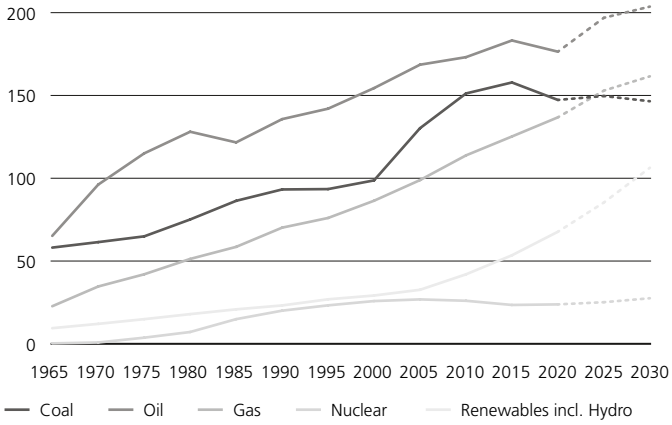
Keeping pace with energy demand growth is becoming increasingly challenging. Many existing oil and gas fields are mature, causing natural declines to exacerbate reservoir depletion from production. Simply holding future oil production flat will require more investment, while at the same time falling short of demand. Energy development is capital-intensive and costly. Further, energy needs to be available everywhere and at all times, requiring infrastructure for efficient storage and distribution. The world's journey to energy transition has begun, but the road may be long and difficult.

The good news is that the current pace of the transition appears brisk, buoyed by the support of governments around the world. We expect the market share for renewable energy to rise at a rapid pace at the expense of coal and oil, the two largest energy sources. Still, fossil fuel resources may retain a major role globally for decades, given their widespread use. Electricity demand is projected to grow most strongly in the coming decades.

Figure 9

Primary energy consumption with projections by 2030

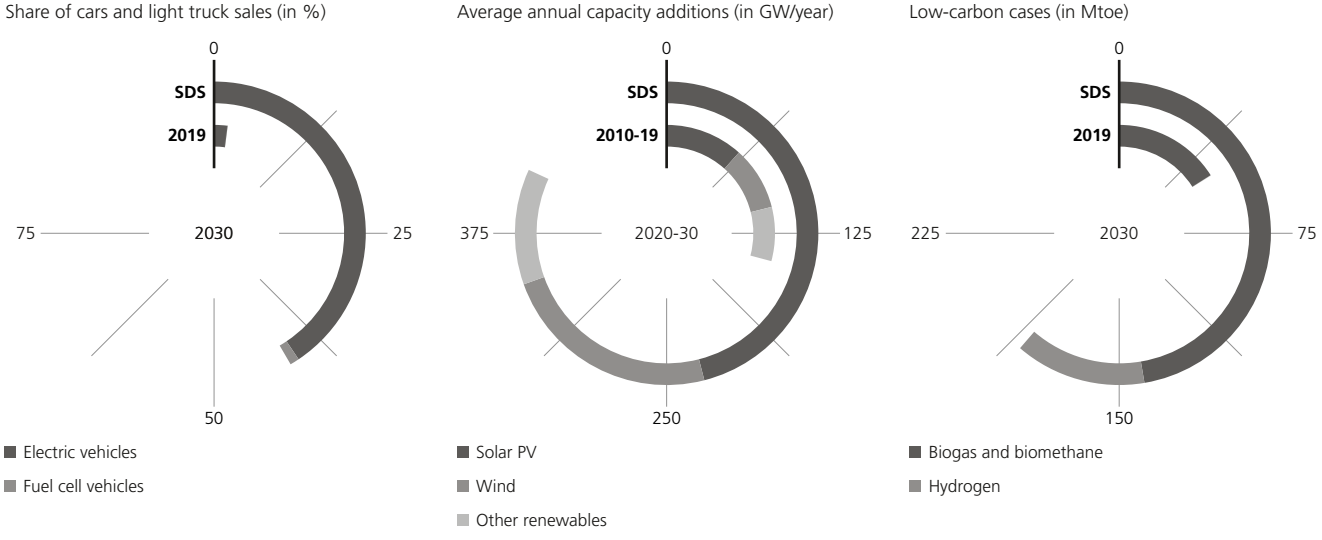
In exajoule



Source: BP Statistical Review of World Energy 2020, International Energy Agency (2020), World Energy Outlook 2020, IEA, Paris, UBS

Figure 10

Growth needed in selected technologies in the IEA's Sustainable Development Scenario



Note: SDS = Sustainable Development Scenario
Source: International Energy Agency (2020), World Energy Outlook 2020, IEA, Paris, UBS

See endnotes on page 66.

Further acceleration in the use of low or no carbon energy is necessary to meet sustainable development goals. Meeting those goals will require an energy transformation of significant magnitude and scope.

Scalable and affordable clean energy technologies in transportation fuels and for industrial use are under development, but many remain immature. For now, ensuring energy security requires a diversified, "all of the above" energy strategy to achieve an orderly and successful transition to a clean and secure future for the earth.

Given popular support and the widespread availability of government-sponsored incentive programs, the pace of the transition to cleaner fuels is only a matter of how much it would cost and how long it would take for new technologies to attain optimal reliability, price, and environmental impact. A viable and sustainable long-term energy solution must be cheap enough both for consumers to afford and for producers to supply in order to maintain market incentives.

Several clean energy solutions that we believe have the potential to substantially reduce energy-related carbon emissions are emerging or gaining momentum. On the next pages we explore such solutions by sector, including technological developments for both transition and efficiency considerations. We have little doubt that the list will evolve as research and development efforts advance.

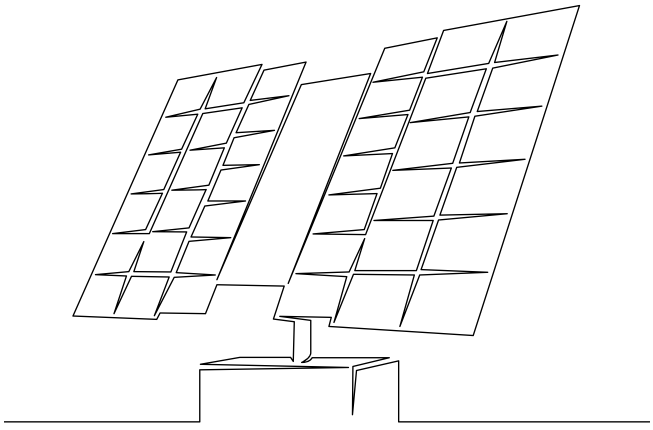
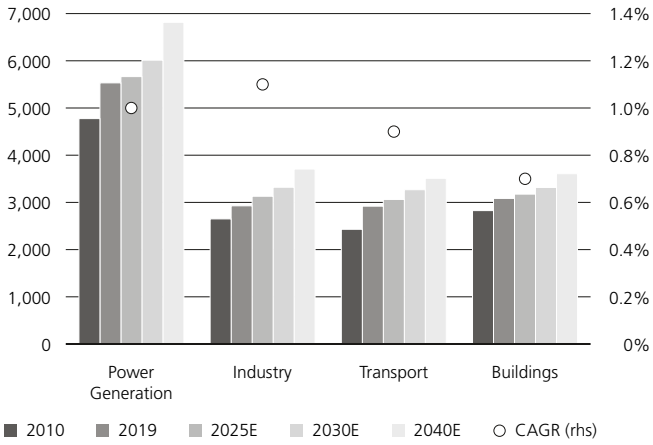


Figure 11

Energy demand by sector

In MTOE

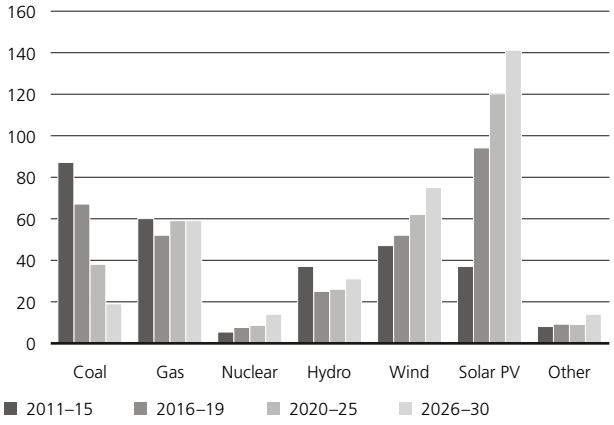


Note: MTOE = million tons of oil equivalent (MTOE); compound annual growth rate (CAGR) represents 2019–2040.
Source: International Energy Agency (2020), World Energy Outlook 2020, IEA, Paris, UBS

Figure 12

Global average annual power capacity additions by energy source

In GW



Source: International Energy Agency (2020), World Energy Outlook 2020, IEA, Paris, UBS

See endnotes on page 66.

Utilities: Electricity demand trends call for cleaner and more efficient technologies

A trend in electrification that has been going on for decades is gaining momentum. Growing electricity demand is driving higher thermal efficiency (more power per unit of energy) in central station power generation like natural gas combined-cycle technologies, as well as renewable energy like hydro power, solar, and wind, with nuclear power still a main source of electricity in many countries. These technologies require the development of electricity storage and related infrastructure.

New technologies like hydrogen also further the prospect of cleaner power generation. However, the shift toward renewable generation could result in a substantial reduction in the security of electricity supply. This is because some renewables are less reliable than thermal or nuclear power generation, as the wind does not blow and the sun does not shine at all times. This challenge to system stability could be very damaging to the reliability of supply consumers expect. Therefore, power companies and grid operators must have flexible renewable energy supplies.

Solutions for power generation

 **Energy efficiency**	More utility companies are pursuing energy efficiency improvements in their own operations, as well as through the customer. Operationally, utilities are replacing old-generation and less energy-efficient technologies. Natural gas combined-cycle technology, for example, has a thermal efficiency of about 65%. This compares with about 40% for coal-fired power plants. At the same time, utilities are promoting energy efficiency to customers through the subsidized supply of more efficient light bulbs, thermostats, and other residential, commercial, and industrial energy management technologies.
 **Renewable power generation**	Solar and wind technologies are, in many parts of the world, the least expensive sources of electricity generation. In the developed world, the growth in renewables is creating redundancies, enabling the reduced use of fossil fuels for power generation. Furthermore, the cost of batteries continues to decline, allowing solar and wind to become more viable sources of clean, renewable, on-demand power. We expect solar and wind, both onshore and offshore, to be the fastest-growing renewable sources of energy over the next decade.
 **Storage**	Battery storage can improve the flexibility of renewables, as the electricity generated can be stored and released during periods with suboptimal sun or wind. While energy storage costs have almost halved in the past five years, they remain costly for large-scale applications. According to UBS Global Research, the average cost of an energy storage battery could fall by three-quarters by 2030. In the future, we see a number of potential new technologies that increase the performance of batteries and reduce unit costs. With substantial reductions in energy storage costs, the addressable market should rise significantly.
 **Nuclear power**	Nuclear power accounted for about 10% of global electricity supply in 2019, and it should grow modestly over the next decade with new plants under construction in several countries. Though nuclear power has one of the lowest carbon footprints per unit of electricity, it remains a costly technology. New facilities are offsetting the shutdown and retirement of existing nuclear plants. In the US and Europe, most of these retirements are being driven by economics and government policy rather than any overt safety concern. New small modular reactor technology is advancing and could be part of the answer to reducing the cost of nuclear power.

See endnotes on page 66.

Transportation: Significant potential for environmental benefits

Transportation demand comprises fuel use for on-road passenger vehicles, trucking, air travel, and shipping. For perspective, there are over 1 billion passenger vehicles travelling over 13 trillion miles per year that run on fossil fuels—namely oil—in the world today. Solutions include alternative drivetrains that rely on cleaner energy such as electric and fuel cell vehicles (EVs and FCVs); biofuels, hydrogen fuel, and other clean fuels for use in internal combustion engines (ICEs); and fuel efficiency gains. EVs are gaining acceptance in regions with supportive infrastructure and incentives to help offset higher EV costs relative to incumbent ICEs. Though fuel cell technology has been under development for a long time, FCVs may become a commercially competitive option. Alternatively, advanced biofuels may represent a cleaner fuel option for ICEs, especially in trucking, as biodiesel supplies are now increasing. Natural and synthetic gas may also become options that work well in longer-range vehicles used in freight hauling. Again, while the technologies have existed for years, scale and cost have been the main hurdles. And lastly, fuel efficiency gains, especially for vehicles that run on fossil fuels, can have a meaningful impact on the amount of fuel the world consumes.

Solutions for transportation

 **Electric vehicles**	EVs have been rapidly gaining appeal, particularly in countries that provide incentives for buyers as part of a mandate to achieve national long-term net zero targets. Battery costs have been a challenge, but have been reduced substantially through technology and adequate material supply. Electric charging technologies will also be integral to this solution, as will the availability of sufficient renewable electricity capacity to enable decarbonization through EVs.
 **Hydrogen and hydrogen fuel cells**	Hydrogen fuel cells have an advantage to electric batteries in terms of charging time and the amount of storage, allowing longer-distance travel on a single charge. This makes this technology attractive for larger vehicles and longer-haul trucks and buses, and possibly for rails, ships, and airliners in the future. Hydrogen is also a zero emission fuel, producing only water as a byproduct. The focus going forward is likely to be on "green" hydrogen production (using clean and renewable feedstocks) or "blue" (using carbon capture with natural gas feedstock) as the energy resource powering the electrolysis process, as opposed to the "gray" hydrogen most widely used today, for which the feedstock is natural gas. Currently, natural gas is the feedstock for 95% of hydrogen production. This more polluting process may benefit from carbon capture in the future. However, challenges for green and blue hydrogen and fuel cells remain in the near term due to their high cost relative to comparable alternatives and the overall lack of charging or refueling infrastructure. Government incentives may be critical to the conversion to green hydrogen. In the meantime, gray hydrogen production should continue to dominate hydrogen supplies.
 **Natural gas**	Natural gas-based fuels for on-road transport include compressed natural gas (CNG) and liquefied natural gas (LNG). Both are mainly challenged by cost factors and the fact that they are not a carbon-free energy resource—they still emit CO_2, even if less so than oil. That said, natural gas will likely continue to be used as a transportation fuel—LNG in long-haul trucking and shipping appears to be a viable option to help reduce emissions—and as a hydrogen feedstock over the intermediate term. Ultimately, hydrogen may also be convertible into synthetic gasoline or natural gas and greatly enhance the world's clean energy solution set.
 **Biofuels and renewable fuels**	Biofuels can be used to replace oil-based products, or as a blendstock in gasoline and diesel fuel. It can be made from organic materials including plant materials and animal waste. Existing first-generation biofuels are produced mainly from food crops such as corn, sugar cane, and palm oil. Advanced biofuels are a better solution, as they are derived from non-food plant feedstocks such as crop residues, agricultural waste, and cellulosic materials such as straw or wood. Another feedstock source is municipal waste such as food scraps, expended cooking oil, and other biodegradable garbage. This synergistic relationship helps to reduce excess garbage, making this option particularly desirable in urban regions. Low-cost feedstock is essential to the emerging advanced biofuel industry.
 **Fuel efficiency gains**	Current technologies offer improvements in fuel economy for vehicles with internal combustion engines, which, when deployed across the global fleet, can significantly reduce fuel consumption over time. In addition, more energy-efficient modes of transportation can result in energy savings, including shared mobility and autonomous driving, and using mass transit or freight rail in place of passenger vehicles and trucks. Urbanization trends can most readily harness beneficial effects through installation of smart and clean infrastructure in the development phase.

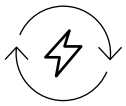
See endnotes on page 66.

Industrial: Heightened investor focus on environmental issues is motivating change

The heightened focus on environmental, social, and governance risks and opportunities has motivated industrial companies to consider sustainable alternatives to mitigate emissions, such as carbon capture. This will not totally eliminate fossil fuel CO_2 emissions, but it will substantially reduce them. Longer term, however, we see hydrogen being the clean fuel of choice in the areas of metals and chemicals to substantially reduce emissions. Steelmakers are increasingly using natural gas, high-grade iron ore, and hydrogen as alternative fuels. We also see an increase in burning waste such as recycled plastics as an energy source—a more desirable outcome for such wastes than clogging up our landfills and oceans.

Carbon capture and storage could pave the way to faster transition in some regions

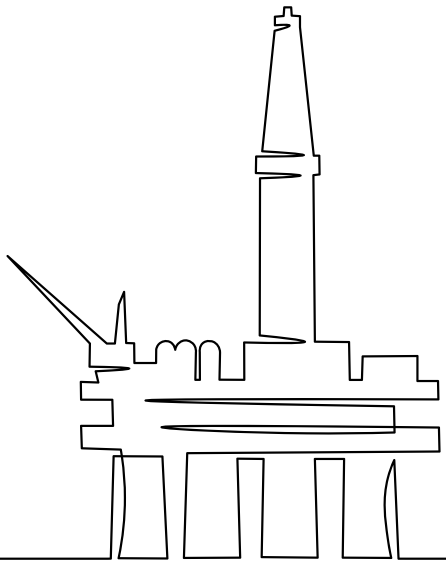
Carbon capture, utilization, and storage (CCUS) entail the removal of CO_2 from an energy source and recycling it either through utilization or by sequestering it safely and permanently. Technologies and research are targeted toward emissions from carbon-based transportation fuels, and toward the CO_2 created or emitted in the fuel production process and in industrial operations. But perhaps most significant is that CO_2 may also be captured from the air around us. To achieve climate change goals, the concentration of CO_2 in the air must be reduced. Therefore, this technology, especially in regions where renewable supply will fall short, will help in achieving climate change goals. Technological advancement in CCUS could gain momentum given its potentially critical role for a wide range of existing and emerging energy sources. This could have a meaningful impact in reducing emissions for large polluters such as China and the US.



CO_2 can be captured from the air around us. To achieve climate change goals, the concentration of CO_2 in the air must be reduced.

Research, development, and application of CCUS, mostly by major oil companies, trace back to the 1980s. Initially, the applications were synergistic in nature through utilization. Recovered CO_2 was, and still is, primarily used to enhance oil recovery by injecting CO_2 back into the reservoir to "push" oil molecules toward the wellbore. In addition, the coal industry has supported research in order to increase the viability of this abundant resource for the long term. CCUS addresses the net negative impact of producing cleaner fuels such as hydrogen and biofuels—both energy-intensive processes—and it can be retrofitted for industrial plants to help reduce carbon emissions.

One of the main hurdles to the more widespread use of CCUS is the cost. For now, deployment of existing technology requires regulatory influence to help address the trade-off between addressing the risk of climate change and paying for the supporting equipment and infrastructure. This will likely be the case for several more years.



See endnotes on page 66.

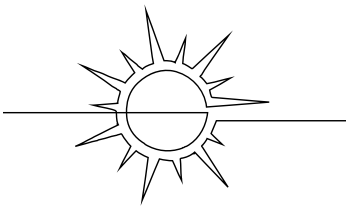
Where to invest

Private investors could find opportunities in companies whose products and services directly address the transition to a low-carbon economy, or those companies that respond to growing regulatory and consumer pressure and manage their carbon footprint effectively.

Energy transition solution providers
For long-term energy investors, we believe opportunities abound, particularly in the renewables sector in emerging technologies such as hydrogen; fuel cells; batteries; biofuels; carbon capture and storage; energy storage and logistics; and energy efficiency. Within private markets, renewable infrastructure development, including large-scale wind and solar farms as well as off-grid electricity networks. provides investment opportunities in real assets.

Investors could also focus on companies that minimize their carbon emissions, use clean energy in their production processes, and are working to meet (or have already met) industry standards on greenhouse gas and climate objectives. This also helps advocate for the management of climate risk in business operations, particularly among such companies as those in the industrial and transportation sectors. Increasing regulation around carbon and climate disclosure, coupled with increasing consumer and investor awareness of climate issues, would encourage companies to be more transparent and enable investors to make more informed decisions.

Poor energy management could be a risk for portfolios
While growth in renewable technologies is attractive, it is not without risk. Managing rapid growth is a difficult task for any company, and the constant evolution of technologies means that incumbent technologies are at risk of competition or obsolescence. We therefore advise investors to be selective and to focus on well-run companies with a sound long-term business model, and to maintain diversified energy portfolios that focus on the renewable industry, anchored by top-quality and environmentally conscientious natural gas and oil companies. A large number of energy companies that are financially strong and deliver stable operational performance also plan to fully engage in the energy transition over time.



SDG 7: Affordable and clean energy
Ensure access to affordable, reliable, sustainable, and modern energy for all

Source: https://sdgs.un.org

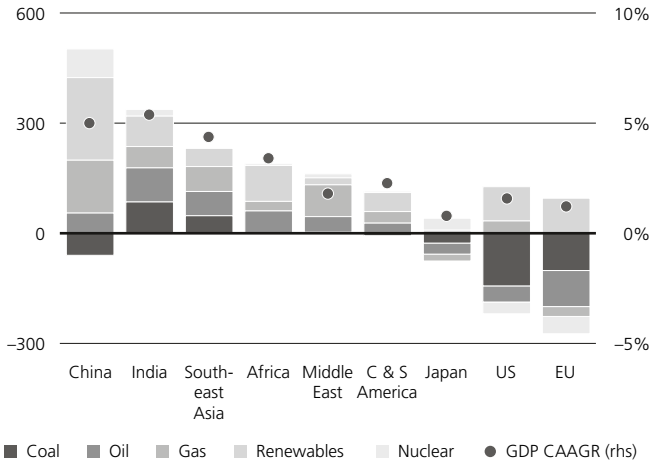
SDG 9: Industry, innovation, and infrastructure
Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation

Source: https://sdgs.un.org

Figure 13

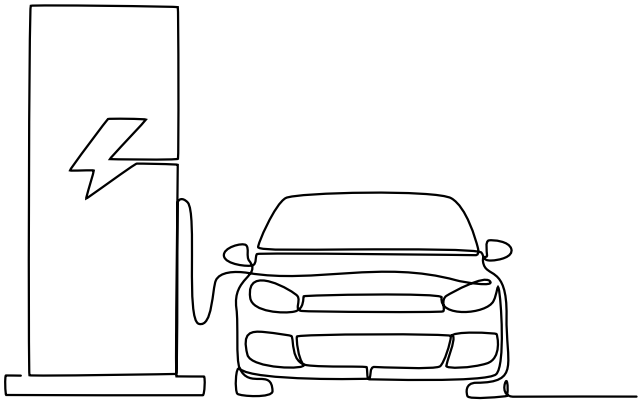
Projected changes in energy demand by fuel and region

In MTOE



Note: MTOE = million tons of oil equivalent (MTOE)
Source: International Energy Agency (2020), World Energy Outlook 2020, IEA, Paris, UBS

See endnotes on page 66.



Regional considerations for investors

Striking the right balance in order to create a sustainable, reliable, and economically viable energy resource base for all stakeholders will be subject to regional influences which will lead to different paths. We believe these influences must be recognized in order to find the best solution that accommodates local needs and optimizes local resources. Across regions, however, renewables are leading the way.

Europe stands out as a leader in the energy transition. The region's rapid transition is buoyed by strong multinational and government support, centered around the European Green Deal and a goal for net zero carbon emissions by 2050. Momentum is most evident in the power generation sector, while the transportation sector is also aiming for all-electric transformation. Infrastructure buildout is relatively unchallenging given the smaller areal extent of nations across the region. Government support has been robust, and Europe-based companies in the industrial, automotive, oil and gas, and utilities sectors are participating in the transition at a high level, promoting more rapid progress.

The United States is the second-largest energy consumer in the world, and policy has long focused on energy security. The Biden administration has committed to carbon neutrality by 2050. That said, establishing long-term goals on a national level is complicated politically by the varied resources and energy needs across the 50 states. Overall progress has been slow and complicated by the extensive infrastructure development required to connect all the states to accommodate a smooth transition.

China, as the world's most polluting country by emissions according to BP Statistical Review of World Energy 2020 and the largest emerging market, captures the essence of the need to balance development and environmental priorities. Despite the government's high-profile commitment to achieve carbon net zero by 2060, which follows the aggressive rollout of green investment and infrastructure policies and incentives over the past five years, the country is adding coal-fired plants even today. Nonetheless, concerted efforts across national, provincial, and municipal governments, as well as the country's global leadership in renewable energy equipment manufacturing and development, put it at the forefront of the energy transition initiative.

Elsewhere in Asia Pacific, and in the Middle East, the share of fossil fuel is moving sideways, but not falling. Part of this is due to the available supply of fossil fuels, the production of which is also critical to national incomes particularly in the Middle East. In Asia Pacific, rapid urbanization is driving elevated energy demand growth, and despite governments' policy commitment to renewables, investment dollars remain split between fossil fuels (including coal) and renewables given mainly economic concerns. According to the IEA, Asia Pacific is the only region that is expected to see growth in coal demand in the coming decade, driven by emerging Asian economies.

Africa is a region in need of support from the international community. Not only is it home to the largest number of people without access to electricity, but its population is also growing rapidly. Achieving universal access to electricity, in accordance with the UN SDGs, will require a high level of investment.

See endnotes on page 66.

External view

Dr. Robert Steinberger-Wilckens

Professor in Fuel Cells and Hydrogen Research, Director of the Centre of Doctoral Training in Fuel Cells and their Fuels, University of Birmingham

Dr. Steinberger-Wilckens, in terms of the world's decarbonization efforts, in which sectors do you see hydrogen and hydrogen fuel cells making the largest contribution?
All of them, based on what science sees. But this does not always lead to the expected outcome. There are often discrepancies between technologies and what is happening in the marketplace. New technologies need to satisfy conflicting priorities. The opposing forces at the moment are cost and a will to reduce emissions. Consumers have to accept higher prices if they want to act on their commitment to carbon reduction. Policy support is needed to make hydrogen cost competitive today, but further technical development will reduce costs in the next few years.

The largest opportunities for carbon reduction are in transportation and in industry. In transportation, hydrogen fuel cell technology is well established, but infrastructure for refueling is lacking in most regions. Industrial activity is energy-intensive, so greenhouse gas emissions are high. The main opportunity is to replace industries' use of fossil fuels with green hydrogen, that is, hydrogen produced from renewable, fossil-carbon-free feedstock. The industrial sector, especially steel and chemicals, wants to "green up." And so the question is, who will bear the higher cost?

There are broader benefits from fuel cells and hydrogen. In power generation, the opportunity is for large-scale fuel cells enabling energy storage to even out fluctuating supply from wind and solar. Production of green hydrogen could benefit all sectors of the economy. Green hydrogen can be processed to replace natural gas and LNG with carbon-free synthetic versions, and also for synthetic diesel to replace oil-based diesel fuel. But today the market cost of green hydrogen is too high for rapid uptake.

Analyzed at a societal economic level (macroeconomics), though, and taking into account cost reductions achieved in market entry over the next years (a maximum of ten), hydrogen will be fully competitive when compared to the full economic cost of fossil energy. This includes all cost of environmental and social impacts of fossil energy. On top of this, fossil energy prices are expected to rise considerably in the future as especially natural gas will be running low as the number of suppliers reduces, with a major part of natural gas in the future coming from Russia, thus building a new monopoly. These circumstances will require a review of perspective, moving from a focus on market prices to rather reviewing the cost to the taxpayer.

Fuel cells have been around for some time, yet we have seen fits and starts in the technology uptake. How is it different this time?
Fuel cells for cars never took off beyond small niches, in part due to costs, but mostly for reliability and lifetime concerns. Both have been improved to the same level as conventional vehicles. Fuel cells can coexist with lithium ion batteries, as each offers benefits and shortcomings. In transportation, fuel cells are best suited for longer-range vehicles, while batteries work better for short-range driving. Consumers will have to pay the price between fuel cells' range advantage and batteries' greater efficiency. Both batteries and fuel cells are more expensive at purchase, but cheaper over a lifetime. Higher-mileage, long-range travel will help to reduce the payback period on fuel cells.

Public perception is that there is room for only one type of battery or one renewable energy source, when in fact there is no one solution. All low-carbon energy technologies can serve a purpose in reaching climate goals and will be required in a portfolio approach to energy supply.

On the path to commercialization, can you talk about what you see from a timing aspect, and what needs to occur in order for this technology to gain acceptance?
Uptake on fuel cells relies on regulation and government support. The technology is there. It's about the initial state support and about the market regulation. Large companies are willing to develop the technology, but are eager to cash in on the funding to reduce their own investment risk. After a two- to three-year period of bearing development costs, they may discontinue development, though. Smaller companies are at risk of being overlooked, but often are technology leaders. A cost on carbon would make hydrogen fuel cells more competitive, though the breakthrough point today requires a carbon cost above USD 100 per ton of CO_2 emissions.

Without government support, adaptation of hydrogen as an energy source will likely be first confined to blue hydrogen, which is produced from natural gas and emits CO_2 when burned and produced. Green hydrogen costs will be competitive in a few years when the cost of renewable electricity has further fallen or fossil energy prices rise again.

Regionally, government programs for hydrogen and fuel cell development are being implemented with effective results. In the European Union and Germany, infrastructure and fueling and charging networks for fuel cell powered vehicles are becoming established. Initial ramp-up is slow but will take off. China, a potentially large market, produces consumption elements, but we see very little visible hydrogen production. Some nations look to hydrogen production as a way to reduce the need to import energy. Japan and Korea are active in pursuit of hydrogen. Fuel cells are being offered by certain automobile manufacturers such as Toyota and Hyundai. Indonesia, Malaysia, and Bangladesh have programs as well. In some other regions, including the US, hydrogen intentions have been expressed, though implementation has not been visible. Globally, there is clearly the potential for a development bank support scheme.

"We know how to grow food without cutting down the forests. We know how to consume food without wasting it. We know how to ensure that people shouldn't go to bed hungry. We have basically all the answers, so the thing really missing is human willpower."

Paul Polman, former Unilever CEO and founder of IMAGINE*

Pexels / Eberhard Grossgasteiger

See endnotes on page 66.

Land

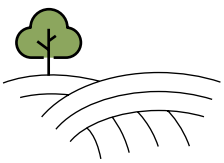
Land use is the second-largest source of emissions globally, according to the OECD, behind only the energy sector. Emissions are generated from land-clearing activity and intensive farming practices. The environmental costs are even higher when one considers the habitat destruction involved and the vital role ecosystems services play in all of our lives—the water we drink, the food we eat, the air we breathe. The unsustainable use of land is making it harder to meet global warming targets, especially as it removes a major consumer of carbon: trees. The good news is that investors and governments alike are awakening to the risks involved in land mismanagement and the accelerating destruction of nature, as well as the opportunities to invest in conservation and land management solutions. We discuss the most compelling prospects in this chapter.

See endnotes on page 66.

At a glance

- **The time is now**
  - Sustainable land use is key to meeting climate targets
  - Climate-smart agriculture faces funding gaps
  - Deforestation and land desertification pose a material threat
  - Protecting biodiversity is crucial to sustain human life and livelihoods
  - Rising demand for food accelerates deforestation and biodiversity loss
- **Where to invest**
  - Land use monitoring and supply chain validation (blockchain, drones, digital data)
  - Smart agriculture (digital tech, biotech, genetic engineering, vertical farming, aquaculture)
  - Sustainable production and consumption (plant-based and lab-grown meat, food delivery, food waste solutions)
  - Companies that take responsibility for and actively address carbon emissions and pollution in their operations and supply chains

- **Land use and biodiversity loss**
  Human action is directly responsible for 80% of land use and biodiversity loss



Conversion of natural forests, shrublands, and grasslands for intensive agriculture and commercial forestry

The time is now

Sustainable land use is key to meeting climate targets
The only greater threat to the planet than environmental risks is weapons of mass destruction—this is according to the World Economic Forum's Annual Global Risk Report. And worryingly, climate change is already having a profound impact on our land and related industries. One oftentimes overlooked yet outsize source of greenhouse gas emissions is land use.

In its landmark Global Assessment Report on Biodiversity and Ecosystem Services, the UN estimates that 75% of the earth's surface has been severely altered by human actions, while the IPCC estimates that about 21–37% of total emissions are attributable to the food system: 9–14% from crop and livestock activities before leaving the farm; 5–14% from land use and land-use change including deforestation and peatland degradation; and 5–10% from supply chain activities, including storage, transport, packaging, processing, retail, consumption, and waste.

According to the World Economic Forum, the destruction of forests is creating almost as much greenhouse gas emissions as global road travel.[29] And 80% of land use and biodiversity loss is directly attributable to the human conversion of natural forests, shrublands, and grasslands for intensive agriculture and commercial forestry. With global agricultural production needing to increase by between 25% and 70% by 2050 in order to feed the swelling global population and agriculture already using almost 50% of the global ice-free land surface, it is clear that one cannot address climate change without addressing agriculture.[30]

Developing countries are, in general, the largest and fastest-growing source of emissions from agriculture. Between 1990 and 2014, they were responsible for the 15% increase in global non-CO_2 emissions from agriculture, while developed countries experienced a slight reduction in non-CO_2 emissions over the same period.[31] According to the World Resources Institute,[32] seven commodities are behind land conversion: cattle, palm oil, soybeans, cocoa, plantation rubber, coffee, and plantation wood fiber. Its research shows these seven commodities accounted for around 57% of agricultural-related tree cover loss from 2001 to 2015.

See endnotes on page 66.

Furthermore, the agricultural system's concentration on just a few crops, plants, and types of livestock (i.e. monoculture) raises the susceptibility of food production systems to disease. Finally, unsustainable agricultural practices drain resources from soil, eventually causing desertification and production loss (land that is being continually degraded).

Climate-smart agriculture faces funding gaps

Climate-smart agriculture is gaining prominence within policy agendas for its perceived "triple win" of raising productivity in food production, adapting to changing conditions (and addressing threats to food security), and mitigating climate change. However, despite the vast potential, disconnects between agriculture and climate policies remain a major challenge; even the Paris Agreement did not directly address these divisions or provide an especially powerful inducement, in our view.

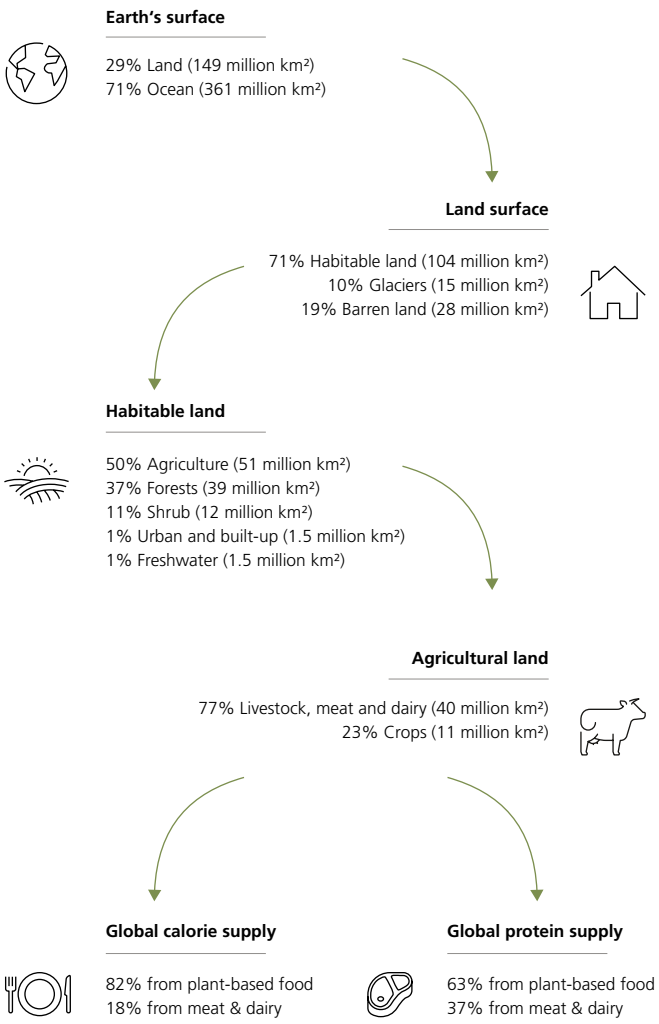
The OECD has put forth four options, which, if implemented into food supply chains, would help mitigate GHG emissions and keep global warming to agreed limits.[33]

- Bring together agricultural practices that reduce agricultural non-CO_2 emissions, including methane and nitrous oxide.
- Introduce practices to remove CO_2 from the atmosphere, to accelerate carbon consumption by vegetation and storage in soils, and to reduce emissions from the degradation and removal of natural carbon stocks.
- Introduce measures that encourage consumers to shift to healthier, lower-emission diets.
- Introduce measures that reduce product losses along food supply chains and food waste by consumers.

However, putting sustainable systems into practice will require substantial innovation in finance, the removal of barriers to entry in adopting new technology, as well as capacity support and data measurement to assess overall progress. It is also imperative to direct funding to where it is needed most. The IPCC anticipates that Africa will be one of the places hardest-hit by climate change, and low- and middle-income countries are already disproportionately impacted by climate-related disasters.

Figure 14

Global land use for food production



Source: Food and Agriculture Organization of the United Nations, 2019

See endnotes on page 66.

Deforestation and land desertification pose a material threat

Forests cover around a third of the world's land. They are home to almost 75% of mammal, bird, and amphibian species, and around 60% of all plants.[34] Tropical forests are biodiversity hotspots and can host 650 tree species per hectare—more than in the whole of Canada and the continental US.

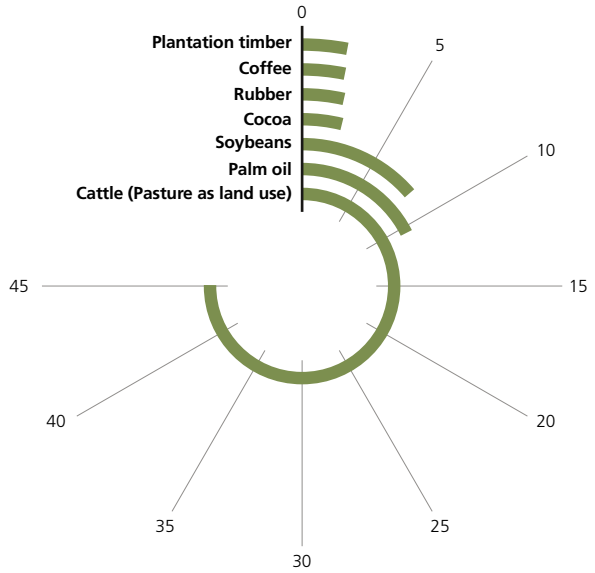
Halting deforestation is the linchpin in limiting the global temperature rise to 1.5 degrees Celsius—the goal of the Paris Agreement—and avoiding the worst effects of global climate change such as land desertification. To demonstrate the magnitude of the problem, if tropical deforestation were a country, it would rank third in CO_2 emissions (including peatland degradation).

Land desertification has both causes and effects—rising global temperatures increase desertification, and land degradation increases climate change. In turn, climate change and desertification degrade ecosystems. The IPBES estimates land degradation undermines the well-being of 3.2 billion people, representing an economic loss equivalent to 10% of global GDP.[35] But, of course, restoring degraded land worldwide would go a long way toward solving the climate challenge. It would help remove greenhouse gases, establish healthy ecosystems, and enable local communities to produce food and secure their livelihoods.

Figure 15

Top seven agricultural commodities linked to deforestation

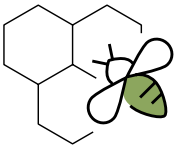
Deforestation in million hectares, 2001-2015



Source: Global Forest Review, World Resources Institute, 2021

Biodiversity in service

Research shows that biodiversity provides an estimated USD 125–140 trillion a year in ecological services



Healthy animal polinators are instrumental in 35% of global crop production

A growing number of investors are recognizing the wide-ranging risks inherent in deforestation and land desertification—including food products, household products, auto components, textiles, and apparel and luxury goods, among others—and are demanding action to mitigate them in the supply chain. In our view, protecting forests is one of the least expensive ways to reduce carbon emissions while bringing countless other benefits like clean air, and healthy habitats and water courses.

Protecting biodiversity is crucial to sustain human life and livelihoods

Human societies and economic activities rely on biodiversity in almost every way. Research shows that biodiversity provides an estimated USD 125–140 trillion a year in ecological services.[36] This amounts to more than one-and-a-half times global GDP. The World Economic Forum and PwC[37] estimate more than half of the world's total GDP (around USD 44 trillion) is moderately or highly dependent on ecosystem services and therefore highly exposed to nature loss.

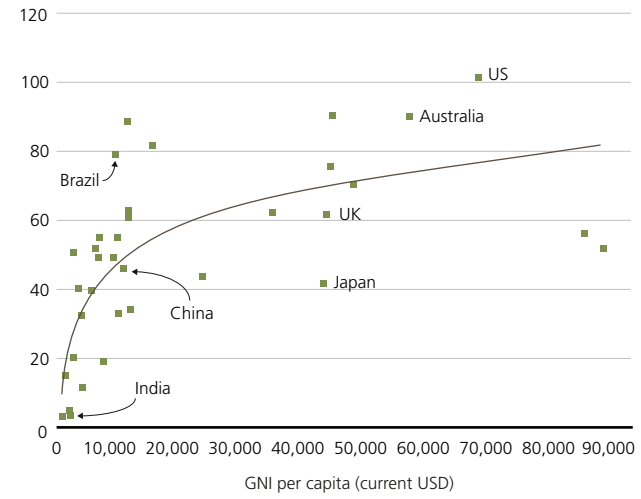
The main point is, everything is related—the health of the planet determines its ability to sustain life. Land degradation and biodiversity loss imperil agriculture and food production. The agricultural industry depends not only on soil, water, and nutrients, but also on healthy animal pollinators—of which bees are among the best-known—which are instrumental in 35% of global crop production.[38]

See endnotes on page 66.

Figure 16

Growth of meat consumption as incomes rise

In kilogram per capita



Note: GNI = gross national income
Source: World Bank, 2018

Rising demand for food accelerates deforestation and biodiversity loss

We will be unable to reverse growing emissions trends unless we address the root cause of land use changes and biodiversity loss—in particular, the rising demand for agricultural products and specifically those that are carbon-intensive.

According the World Resources Institute,[39] there is a shortfall between the amount of food we can produce today and the amount needed to feed everyone by the middle of the century. Moreover, to hold the global temperature rise to below 2 degrees Celsius, it will require global agriculture and other land-users to reduce emissions by two-thirds, including halting agriculture-driven deforestation. To stay below 1.5 degrees Celsius, large areas of land would need to be reforested while agricultural productivity accelerates and consumption patterns change, i.e., toward eating less resource-intensive, animal-based foods.

What is biodiversity?

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) describes the variability among living organisms from all sources, including terrestrial and aquatic ecosystems, and the ecological complexes of which they are a part. This includes variation in genetic and functional attributes, as well as changes in abundance and distribution within and among species, biological communities, and ecosystems.

The scientific journal Nature describes biodiversity as the whole of three components: species diversity—all living organisms, from single-celled microbes to plants and animals; genetic diversity—the differences in genetic characteristics and traits of populations, which can help species better adapt to changing environment and fight diseases; and ecosystem diversity—all species in a region and how factors such as soil, temperature, and rainfall determine the type of species and their morphology, behavior, and interactions.

See endnotes on page 66.

Governments and industry are converging on sustainable business practices

- China officially put the Environmental Protection Tax Law into force, providing a list of taxable pollutants and outlining how environmental taxes will be calculated for all business activities (2018).
- The New Zealand Zero Carbon Act—the first legislation in the world to make a legally binding commitment to living within 1.5 degrees of global warming—sets agriculture-specific targets to reduce methane emissions (2019).
- The European Commission unveiled its "farm-to-fork" and biodiversity strategies as part of the European Green Deal (2020).
- The Roundtable on Sustainable Palm Oil, which seeks to ensure the integrity of the trade in sustainable palm oil, now certifies around 20% of globally traded palm oil.
- The US Soybean Export Council, which runs the Soy Sustainability Assurance Protocol, has set significant biodiversity targets for US soybean farmers regarding land use and soil erosion impact.

Solutions for the future

Tackling environmental issues and biodiversity loss is a huge and complex task.

To reduce environmental harm and systemic risks, we need to rethink how we produce and consume the food we eat and the clothes we wear, their respective supply chains, and how we live. We need to enhance sustainable supply chains and trade. While definitions vary, fair trade labels and organic food certifications help give the assurance that the products we consume have been produced in a sustainable way, including the fair treatment of workers and care of the earth.

The actions of various parties—including regulators, consumers, and financial institutions—are increasingly dedicated to these sustainable outcomes.

Industries and companies across the supply chain have started to respond to consumer demands for more sustainable products. For example, a major UK supermarket chain no longer sells Brazilian beef due to its claimed contribution to deforestation; some well-known clothing brands have committed to using fiber that in the production process takes into consideration environmental and social impact; and many food manufacturers have stopped using palm oil in their products on grounds of land degradation and biodiversity loss.

Consumers are also becoming increasingly conscious of their behaviors. Some try to eat less meat and more plants and reduce food waste as they become aware that forests are often cleared to create fields for livestock or to plant soybeans and corn to feed livestock. They look for products with recycling logos and sustainable or responsible business certifications and insist their suppliers disclose the source of raw materials.

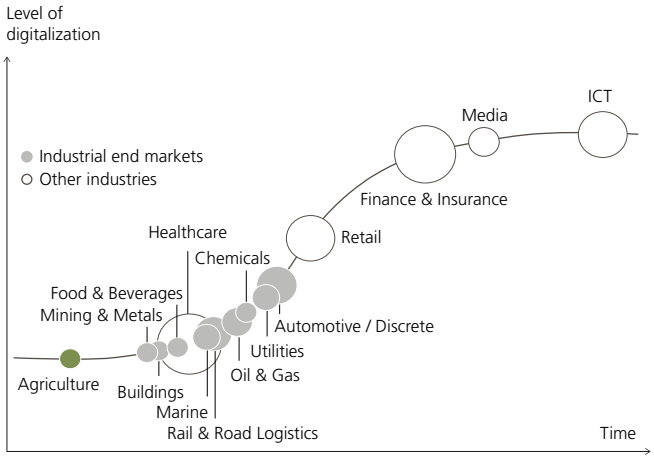
See endnotes on page 66.

While investors and individuals are increasingly asking how they can play a role, attracting investment into areas like sustainable agriculture and forestry is not easy. Nevertheless, we are witnessing innovation and technological disruption already advancing quickly in traditional agriculture. A good example is the focus on global carbon accounting systems and technologies to measure soil carbon. Furthermore, farmers are increasingly operating sustainably by using natural and digital solutions, limiting the use of inputs and replacing monoculture with polyculture farming practices. Investors can consider opportunities to actively invest in the conservation, restoration, and sustainable management of forests, farmlands, and wetlands.

While not in the scope of this report, innovation in the areas of environmental finance may be considered as well. Environmental programs often have long-term goals that require long-term funding. For example, venture capital-type investments can support profitable business ideas while providing measurable results. Blended finance is another approach to scaling up venture capital-type investments.

Figure 17

Digitalization of agriculture compared to other sectors

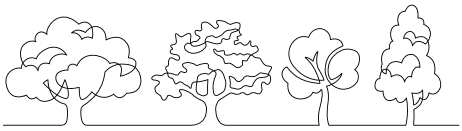


Note: ICT = Information and Communications Technology
Source: UBS, 2019

Where to invest

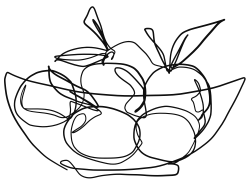
To sharpen our focus, we present investment areas in three main areas: land use monitoring and supply chain validation; smart agriculture; and sustainable production and consumption. Overall, we estimate these segments should be worth at least USD 700 billion by 2030 (from USD 135 billion in 2018).

Many investors have shied away from the industry because of perceptions that the value chain is complicated and too nuanced, and because the commercialization of new technologies has historically been hit-or-miss. Furthermore, significant capital flows into areas such as alternative protein have largely focused on early-stage private startups—mostly plant-based business-to-consumer (B2C) companies—leading to what may already be questionable valuations. However, we see significant opportunities for investors willing to explore them, particularly as investment in agriculture and other parts of the innovation chain lag behind other tech-driven segments like healthcare.



SDG 15: Life on land
Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss.

Source: https://sdgs.un.org



SDG 2: Zero hunger
End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

Source: https://sdgs.un.org

See endnotes on page 66.

Monitoring and supply chain validation

As most consumers are not aware of how the food they eat gets to their table, a range of technology-driven data platforms are being developed across the supply chain to improve the traceability of food, reduce waste, and raise the efficiency of marketplaces. Distributed ledger platforms like blockchain offer a powerful way to improve the traceability of food. Doing so can reduce waste, improve food provenance, and build consumer trust in the industry. Some Chinese e-commerce giants, for example, have launched blockchain platforms that allow consumers to scan QR codes on product packaging and receive detailed information including the source farm, the journey along the supply chain, and information about product inspections.

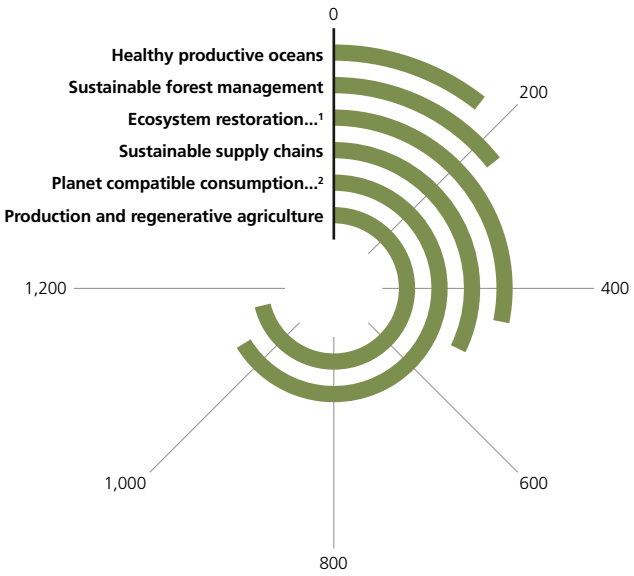
Rather than relying on physical inspections and audits, tech surveillance can be used to monitor whether commodities are being produced sustainably. Tech-enabled certification may be needed to meet the growing demand for certified commodities. It can also facilitate the monitoring and detection of unsustainable agriculture practices. The COVID-19 pandemic has strengthened the case for virtual or remote monitoring, as physical inspections may not always be practical.

For example, drone technology is already widely used to monitor crops, apply crop protection products, and fertilize land. However, we are now seeing a growing opportunity for the use of geospatial data from drones or satellites to monitor deforestation and to ensure commodities are produced sustainably. We see opportunities not just in the satellite or drone data itself, but in the tech solutions analyzing the data. Companies like Orbital Insight can monitor forests and plantations and detect unusual activity, such as movement in protected zones or even illegal deforestation. Others like Starling use optical and radar satellites to monitor forests and detect deforestation.

Figure 18

Expected business opportunities behind key transitions by 2030

In USD billions



[1]...and halting additional expansion
[2]...(i.e., eating less animal protein)
Source: World Economic Forum, 2020

The use of geospatial data should prove increasingly popular with consumer brands seeking more transparency over their supply chains. And now that regulators are looking to make biodiversity standards enforceable by law, companies are being more proactive in ensuring that their supply chains are free from unsustainable production practices.

See endnotes on page 66.

Climate smart agriculture

Digital solutions are helping to make traditional farming more efficient and less resource-intensive. Examples include precision agriculture, which raises output while minimizing the environmental impact and irrigation technology, which can enhance farmers' decision-making and reduce water consumption. Water scarcity is driving solutions to consume water more efficiently through the use of combing sensors, drones, big data, satellite connectivity, and robotics. Connectivity to reliable data networks remains a key impediment, particularly in remote locations and developing countries. While digitalization of the sector as a whole remains low, it's a strong candidate for extensive technology transfer from other segments like electric vehicles and autonomous driving.

Likewise, new-generation biotech such as CRISPR, a gene-editing technology, could be instrumental to producers battling agronomic challenges and climate change. Biotech can also be used to reverse soil degradation, which has positive knock-on effects for biodiversity. Irish start-up MicroGen has developed microbial products that can be used to rejuvenate degraded land via a process of "bioremediation". Additionally, food can be designed to, among others, have greater functional benefits for human health and improve the shelf life of produce.

Outside traditional farming, the past decade has also seen the rise of vertical farms and robotic large-scale greenhouses. Companies like 80 Acres Farms in the US, Spread in Japan, Infarm in Europe, and Sustanir in Singapore are seeking to reduce carbon emissions associated with transportation by locating facilities near the point of consumption while minimizing the usage of other resources like water, chemicals, and fertilizers. Still, vertical farming has its limits and may not be a viable solution for all crops.

Other areas to consider include new agricultural models emerging in regenerative farming systems and high-tech aquaculture such as alternative water-based sources of protein like algae. Livestock producers are also trying non-soy-based animal feeds to address biodiversity concerns. This may accelerate growth in the insect protein market.

Sustainable production and consumption

Shifting consumer preferences will also play a role in reducing the carbon intensity of our food system. There is growing support for the thinking that dietary patterns need to converge around diets based more on plants, owing to the disproportionate impact of animal farming on land use and the environment—a shift that could also help reduce the risk of pandemics. There is also an increasing awareness and effort to reduce food waste. Together, these measures would reduce pressure on resources, including land, by reducing demand.

Millennials are fast becoming the most influential consumer group.[40] They see food as a social currency, have less allegiance to brands, and buy products that resonate with their beliefs and values. To this cohort, we think diets and foods with lower ecological footprint, such as vegetarian, vegan, and lab-based alternatives, will gain in popularity. The COVID-19 pandemic has likely added to this momentum, having shined a spotlight on issues associated with sustainability, animal welfare, transparency, livestock farming, as well as their impact on the environment.

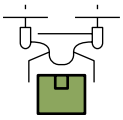
See endnotes on page 66.

Three key areas have emerged in alternative proteins: plant-based analogues, cultivated meat (meat grown from cells in a bioreactor), and precision fermentation (proteins grown by fermentation). These technologies are rapidly improving in terms of outcomes and cost, promising to offer new and improved foods that can scale to feed our growing population and help reduce the climate impact of traditional meats. We expect the market for plant-based protein alternatives to expand by 28% a year on average over the next decade, reaching USD 85 billion by 2030.

Companies like Netherlands-based Mosa Meat, for example, uses self-reproducing cells to produce meat that is an "animal-based" product while avoiding the need to breed, raise, and slaughter huge numbers of animals. Other companies like Shiok Meats are focusing on cell-based seafood, aiming to replicate shrimp cells in a laboratory. GALY, a US start-up has been leading the way in the production of lab-grown cotton, which is grown from cells, formed into fibers, and then spun into a fabric. C16 Biosciences brews an alternative to palm oil from microbes. In fact, all lab-grown produce reduces the threat of deforestation, the use of land, soil degradation, and the use of harsh chemicals (pesticides and fertilizers). At this stage, we see synthetic produce as a way to supplement traditional production methods rather than as a replacement.

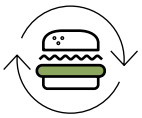
Digital marketplaces should also grow in prominence as urbanization takes consumers further away from their food. "Food-hailing" and other emerging logistical platforms could dramatically change the way we buy and eat food. Autonomous droids and drones may further boost the industry's last-mile coverage. We expect this segment to expand by 16% a year on average over the next 10 years, to become a USD 365 billion market by 2030. However, we need to be mindful of the potential negative impacts such technologies could have on carbon emissions as a whole.

- **"Food-hailing" of the future**
  Autonomous droids and drones may boost the food industry's coverage; we expect this segment to expand by 16% a year on average over the next 10 years



USD 365 billion
market by 2030

- **Plant-based protein**
  We expect the market for plant-based protein alternatives to grow by 28% a year on average over the next decade



USD 85 billion
market by 2030

See endnotes on page 66.

External view

Suzy Amis Cameron

Environmentalist, entrepreneur, and UBS Global Visionary

Ms. Amis Cameron, One Meal a Day empowers individuals to help the planet and their health through their choices. How can plant-based diets play a role in improving the health of humans and of our planet?
Studies have shown that a plant-based lifestyle improves the quality of life in many ways—better sleep, more energy, better ability to fight disease. It can significantly reduce the risk of diabetes, heart disease, and cholesterol. Research has also shown that animal agriculture pollutes more than all transportation combined. Going plant-based is the easiest way to help the planet. The idea of letting go of their meat-eating habits might be frightening to some people, so a simple, elegant solution is to swap one of your meals each day for a plant-based meal. One Meal a Day empowers all people of all ages to do their part for the environment and their own health.

We've been seeing tremendous innovation in plant-based foods. What's your view on the future of plant-based eating?
As people understand that plant-based eating is beneficial to their health and can literally save the planet, more innovation in plant-based protein is going to come. Companies are developing really tasty meat substitutes, yogurt, and cheeses using pulses, which are great sources of protein, very water efficient and amazing at nitrogen fixation. These will keep on getting better to a point where people eventually won't miss regular cheese and yogurt anymore. There are more and more people consuming plant-based, even if as part of a broader diet, because of innovation in the segment.

The pandemic has emphasized the role of food in shaping our lives. With an increasing focus on sustainable and ethical solutions, where are the opportunities to further transform the way we consume? Where do you see the gaps, and what role can investors play?
Not only was this pandemic (and many others) created by the exploitation of animals meant for human consumption, but people have noticed the value of locally sourced food and the impact that can have in our existence. Consumers aren't satisfied with simply buying plant-based. More and more, they want to know where their food comes from, how it's produced, its impact on the environment. These are the things that millennials, Gen Z, and the soon-to-be decision-makers Gen Alpha are taking notice of. Investors should turn their attention toward companies that produce healthy, ethically sourced foods and add value to the production chain. The larger the investment in plant-based, the more people will know about it and consume it. We're leaving the era of the "I" and entering the age of the "we." Keen investors will realize that the future is in investments with purpose.

This statement contains views which originate from outside Chief Investment Office Global Wealth Management (CIO GWM). It is therefore possible that the statement does not fully reflect the views of CIO GWM.

"The main challenge behind clean water and sanitation is that people still don't talk about it as a normal subject. Sanitation—hygiene, handwashing, how you treat the sewage—is the cheapest medicine in the world."

Jack Sim, founder of the World Toilet Organization*

Pexels / Kaique Rocha

See endnotes on page 66.

Water

Agriculture consumes nearly 70% of one of our most scarce resources: accessible fresh water. Rising populations, improving living standards, ongoing urbanization and industrialization in emerging markets, as well as changing supply patterns due to climate change will intensify the pressure on global water allocation. Failure to manage the planet's limited drinking water resources will have huge social and economic costs. The flip side to this scenario is that, if the world can harness its limited water resources, the benefits to mankind will be enormous and translate into a convincing investment case. The size of the global water market was estimated at USD 655 billion in 2020, and this is expected to grow at a mid-single-digit annual rate over the next few years.[41]

See endnotes on page 66.

At a glance

- **The time is now**
  - Population is growing and living standards are rising
  - Urbanization and industrialization become key in emerging markets
  - Climate change has a negative impact on water supply
  - Water scarcity is getting worse for many regions and large parts of the population
- **Where to invest**
  - Smart water networks
  - Water automation systems
  - Water meters
  - Water testing equipment
  - Desalination equipment
  - Companies that effectively manage their water consumption in operations and supply chains

- **Water abundance**
  While 71% of the Earth is covered by water, only 2.5% is freshwater

69% of the world's freshwater is locked in glaciers or frozen ice caps

The time is now

Water is abundant on a global scale. Seventy-one percent of the Earth is covered by water; however, only 2.5% of the world's water is freshwater, and of this, 69% is locked in glaciers or frozen ice caps. Even the remaining amount is not easily accessible as it is bounded in ground ice and permafrost.[42] Thus, the amount of water suitable for human consumption is limited, and the resource is unevenly distributed. Despite this inflexible supply, demand is constantly growing. Since the beginning of the 20th century, from 1900 to 2010, global water withdrawal increased 7.3 times, whereas the world population grew 4.4 times.[43]

Long-term developments such as a growing population, rising living standards, industrialization in emerging markets, and a lack of infrastructure heavily affect water supply and demand. Climate change is another vital factor influencing the global water supply in terms of quality, quantity, and timing. The UN estimates that 2.2 billion people lack safely managed drinking water, and nearly 700 million could be displaced by 2030 due to water scarcity.[44]

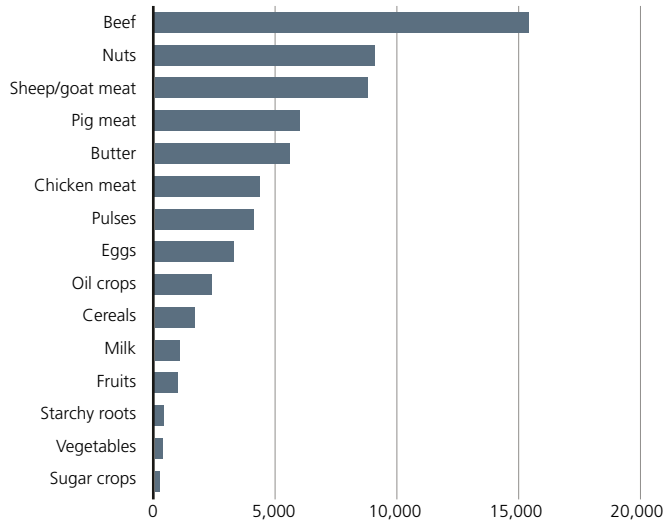
Population is growing and living standards are rising
A larger population increases overall consumption and thereby demand for water. The obvious direct effect is a higher demand for drinking water, but the indirect effect—food production—is an even bigger challenge. The ever-larger population will also need sufficient calorie intake. Not only higher quantities, but changing dietary preferences will also impact demand for water. Protein-rich nutrition based on animal products will further increase water demand, particularly in countries with growing middle classes and meat consumption. Scientists at the Swiss Federal Institute of Technology compared a pure vegetarian diet with one that includes meat consumption. A diet containing 20% meat almost triples the amount of water usage by an individual per year. Higher living standards not only alter dietary patterns, but also increase the "personal water bill" through higher demand for personal hygiene and other types of cleaning.[45]

See endnotes on page 66.

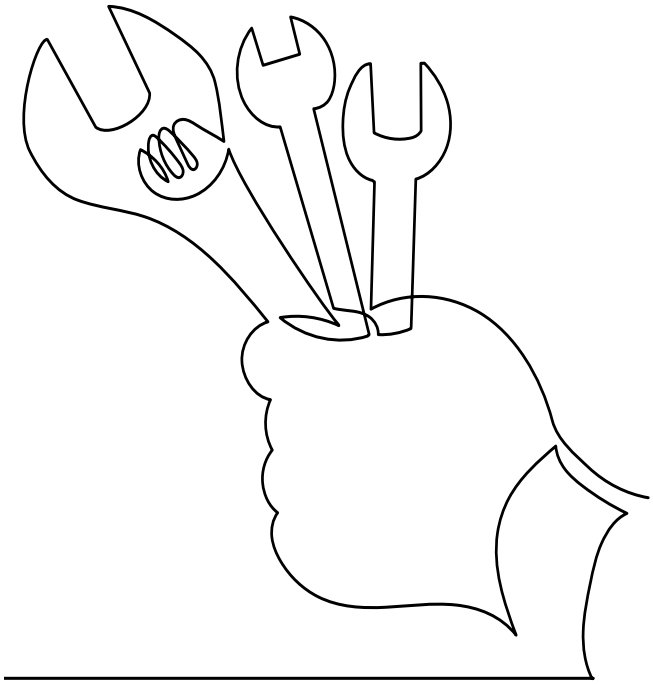
Figure 19

Water requirement per kilogram of product

In liters



Source: Mesfin M. Mekonnen and Arjen Y. Hoekstra, "A Global Assessment of the Water Footprint of Farm Animal Products," Ecosystems, 2012, https://doi.org/10.1007/s10021-011-9517-8



Urbanization and industrialization become key in emerging markets

Additional water demand stems not only from a growing urban population, but also the increasing size and number of industrial parks. Many emerging markets are pursuing a strategy of industrialization which accounts for their disproportionately higher use of fresh water. Another result of urbanization and industrialization is the growing thirst for energy in big cities. Many types of electricity generation consume water during the generation phase. Large thermal power plants in particular require significant amounts of water for their cooling operations.

Many emerging market cities need to build completely new water infrastructure. One of the obstacles is that, compared with other infrastructure investments, it is very capital-intensive, i.e., it demands high initial capital expenditures followed by a very long payback period. Also, the investment needs for water infrastructure are significantly larger than for telecommunication, land transportation, or electricity transmission and distribution, according to the OECD.[46]

In developed markets, the problem often lies in existing infrastructure. Many industrialized countries built their water mains in the early part of the 20th century and have not invested extensively in upgrading them since. The average lifespan of water pipes is 50 to 100 years, depending on the material they are made of and how much pressure they handle. Such aged infrastructure means water leakage is a problem. According to the OECD, water utilities in member countries have a water leakage in the range of 10–30%. In developing countries, water leakage of up to 40% is not uncommon, and some reach even 70%.[47]

Compared to developed markets, where many governments have postponed big investments in water infrastructure for decades, emerging markets have little choice: They must invest. Consequently, we see the biggest opportunity in emerging markets.

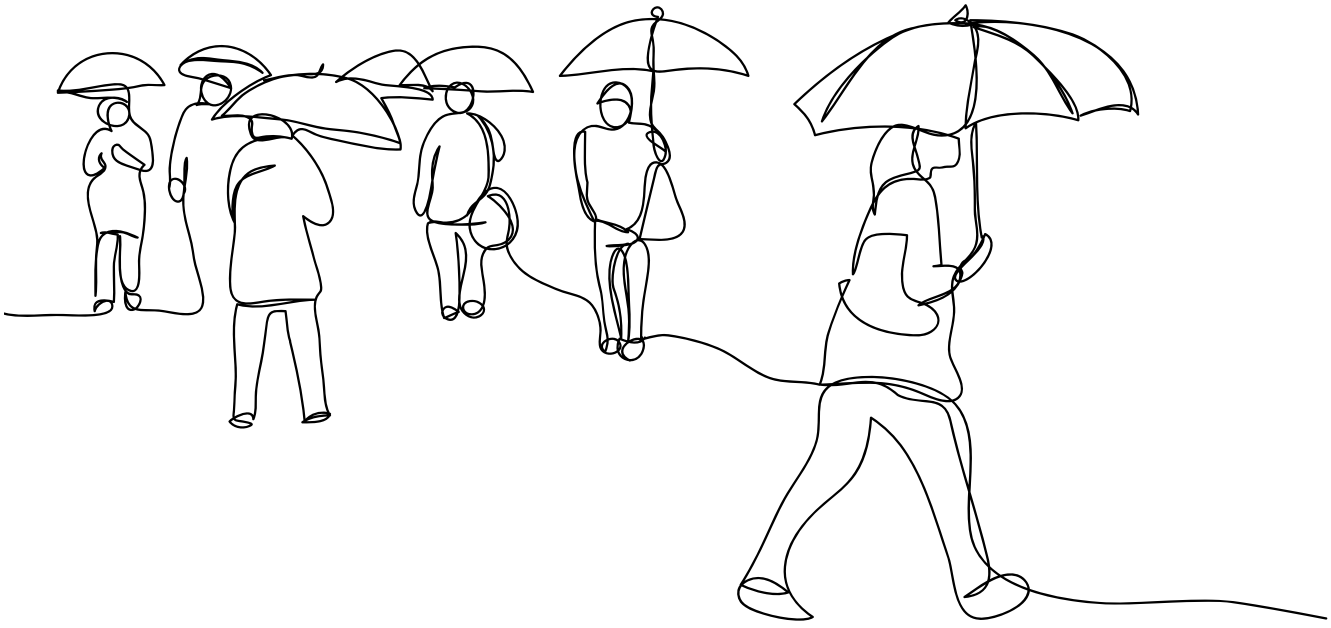
See endnotes on page 66.

Water shortage in Cape Town

The water shortage in South Africa's Western Cape in 2017–18 serves as a cautionary tale. In February 2018, Capetonians were asked to limit their daily water use to 50 liters per person per day, down from the mandate of 87 liters in July 2017. Before the drought, Cape Town's population used about 200 liters of water per person per day. Thanks to enough rain during the winter season, the city gradually relaxed the restriction to 105 liters per day in December 2018.[49] Cape Town is just one example. Insufficient water infrastructure amid rapid urbanization, changing rainfall patterns due to climate change, and inefficient use of available resources can result in major water crises directly affecting the population and economy.

Climate change has a negative impact on water supply
The frequency and uncertainty of floods, storms, droughts, and extreme rainfall affect the planet's water system. Water stress already affects all continents, but not all regions will be impacted in the same way. Water scarcity is in many regions only a seasonal problem, but climate change will alter these patterns for the long term. Melting glaciers, for example, may increase streamflow locally in the near term, but will lead to more variability and a lower baseflow in rivers in the long term. A change in peak flows in snow-dominated rivers is already observed in several regions. Cities will be heavily impacted by climate change due to their high population density. By 2050, more than 570 cities with a total population of 685 million will face another decline in freshwater of at least 10%. Cities like Cape Town and Melbourne may see declines of 30–49%, while Santiago could face a decline of more than 50%. This will have a major negative impact on the GDP of certain regions worldwide.[48]

Climate change will also impact the agricultural sector, the largest consumer of freshwater today. Higher temperatures often also lead to a higher demand for water, making it more difficult for governments to balance demand and supply. But warmer temperatures will also accelerate evaporation from land and sea, and consequently result in more flooding since the atmosphere holds more moisture. Droughts in low-precipitation areas are equally likely. Thus, climate change is not only a reason for water scarcity, but also for water overflow. Each region will see a different impact.



See endnotes on page 66.

Water scarcity is getting worse for many regions and large parts of the population

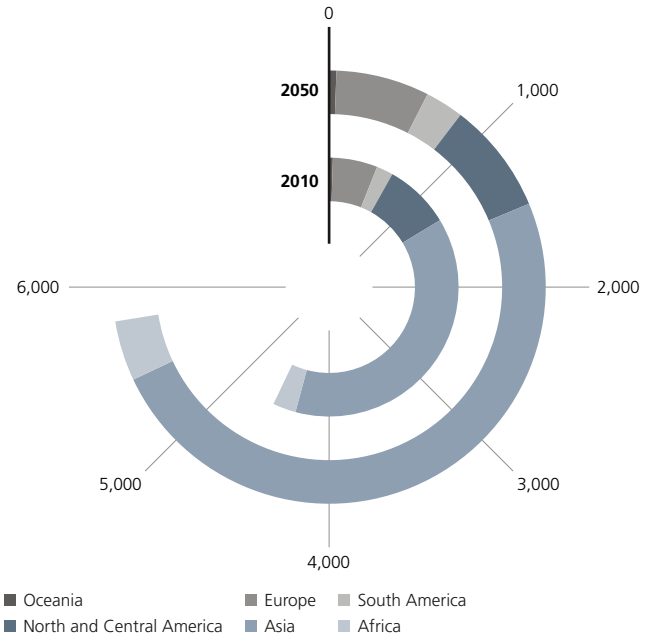
The water demand forecasts for the coming decades vary by agency, but there is consensus that much of the growth will come from industrial and municipal (domestic) sectors.[50] Scientists working on the Water Futures and Solutions Initiative[51] estimate a 20–33% increase in water demand across different scenarios from 2010 to 2050.[52] The strongest increase is expected in Africa (up to 60%), South America (up to 40%), and Asia (up to 30%) due to population and income growth, making emerging markets a potentially attractive region for investments in water infrastructure.

The growth in water consumption also has a direct impact on the number of people living in water-scarce regions. Taking into consideration the monthly deviation between supply and demand, 3.6 billion people—half of the world's population—already reside in areas with potentially severe water scarcity, and this number could increase up to 5.7 billion by 2050.[53] The most impacted will be Sub-Saharan Africa (Western and Eastern Africa), as well densely populated regions in India and China where water scarcity is already a problem today. In general, most countries will be impacted in the Northern Hemisphere from 10 to 40 degrees latitude. In the Southern Hemisphere, South-Western Australia and Western South America are already water-scarce hotspots.[54]

Figure 20

Water demand by continent under the Middle of the Road scenario

In cubic kilometers per year

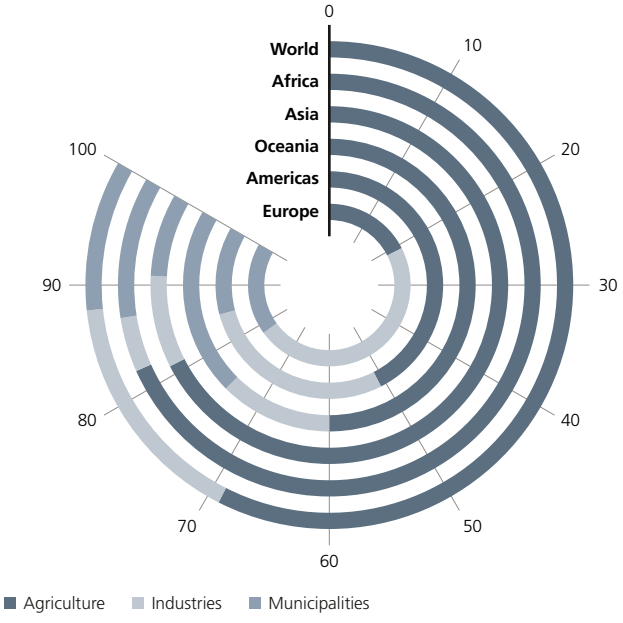


Source: "Water Futures and Solution - Fast Track Initiative (Final Report)," IIASA Working Paper, 2016

Figure 21

Water withdrawal ratios by region

In %



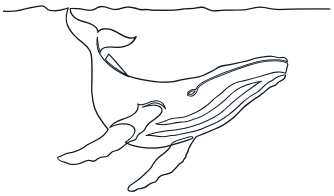
Source: Food and Agriculture Organization of the United Nations, Water use (2015). Extracted from: http://www.fao.org/aquastat/en/overview/methodology/water-use/ in 2020.

See endnotes on page 66.

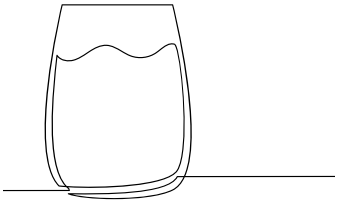
Solutions for the future

In our view, water utilities and industrials alike should benefit from rising water demand, the former through higher water tariffs, capacity expansion, industry consolidation, and higher demand for wastewater treatment particularly in urbanizing and industrializing emerging markets, and the latter mainly through more equipment sales.

Like other industries such as agriculture, the water sector is increasingly using digital technology to better manage facilities. Water utilities are using management systems to collect and analyze data, and act upon them. Smart water meters measure relevant factors (e.g., flow, temperature, and pressure) that help water utilities run their facilities more efficiently. Depending on how advanced the technology is, they could also adjust tariffs to better balance supply and demand during peak hours. These tools for asset optimization will not only improve the efficiency of operations, but also increase the automation of facilities. Larger water utilities, for example, use smart cloud platforms to analyze and optimize their networks of water plants. Another important improvement is water leakage detection, which is a major problem in many big cities worldwide. Water utilities use sensors to identify in real time if there is a leakage, and can act immediately to solve the problem. This helps them save costs and resources.



- **SDG 14: Life below water**
  Conserve and sustainably use the oceans, seas, and marine resources for sustainable development



- **SDG 6: Clean water and sanitation**
  Ensure availability and sustainable management of water and sanitation for all

Where to invest

Private investors could capture opportunities in water by investing in solution providers such as utilities and smart water networks, and in companies that effectively manage their water consumption.

Water solution providers offer attractive growth rates
No single water market exists. The water market consists of several subsectors that can broadly be split into two groups: industrials and water utilities. RBC Capital Markets estimates the world water market at around USD 655 billion as of 2020. The biggest category, accounting for 29%, is wastewater treatment (water utilities). The remaining 71% consists of equipment suppliers for water exploration, distribution, and treatment. Broadly speaking, like mining and oil and gas companies, water industrials and utilities are both equipment end-users (demand side) and providers (supply side) that should benefit from these and other water-related investments.

Based on RBC estimates, the most attractive end-markets from a growth perspective are smart water networks, with an expected average growth rate in the high teens on a three- to five-year timeframe, and water automation systems and water meters, with annual growth rates of around 10% and 11%, respectively. The slower growing subsectors (low- to mid-single-digit average growth rate) include water chemicals; industrial and residential water treatment; waste and wastewater treatment; and water engineering and consulting. All other subsectors are expected to grow 6–9% on average each year.

See endnotes on page 66.

The attractive business prospects and high revenue visibility of water utilities (which are often local monopolies) and the diversity of water-exposed industrial companies are the main reasons we think investors should include them in their portfolios.

Companies that actively address their water consumption are set to benefit from growing regulation and interest from sustainable investors

Addressing water consumption in operations could help manage risks and improve profitability. Water consumption is especially critical for companies that require a vast amount of water for their activities, such as those in the agriculture, utilities, and consumer staples sectors, especially the food and beverage and household product industries. They are often exposed to increased water regulation, as well as high costs of water driven by inefficiency in operations. Investors could actively manage these risks and take advantage of improvement opportunities by choosing companies in relevant industries that manage their operational water footprint better than their peers. Key indicators such as water intensity, consumption trend over time, and disclosure on water-related metrics could serve as valuable input when making investment decisions.

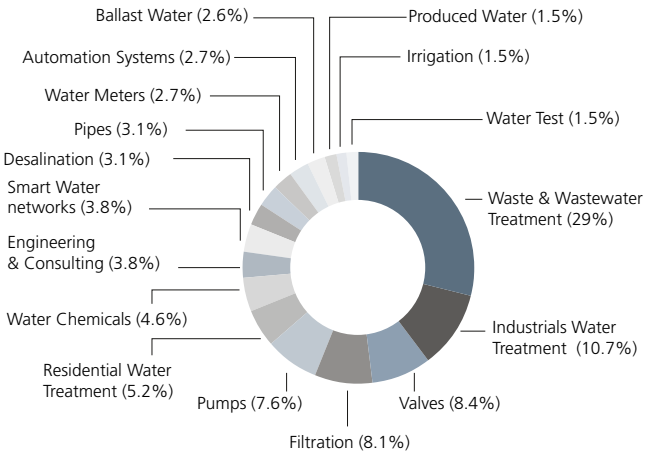
Water scarcity can be a risk to portfolios

Water shortage is also an important risk to watch in your portfolio. Whether as a direct or indirect input in production, water must be distributed efficiently to keep businesses and economies running. Therefore, water-related issues should be taken into account in a corporate analysis. Examples of insufficient water supply affecting business can be found around the world. Drought and water shortages have forced companies across sectors to shut down or relocate production. In Latin America, some have had to compete with local communities on issues related to water, resulting in unrests. Companies can insure against water-related risks such as damage due to floods or crop shortfall due to drought—those in higher-risk areas face rising insurance premiums and thus operating costs—but other risks such as changing regulation cannot be insured. It is therefore important to consider these risks in investment decisions.

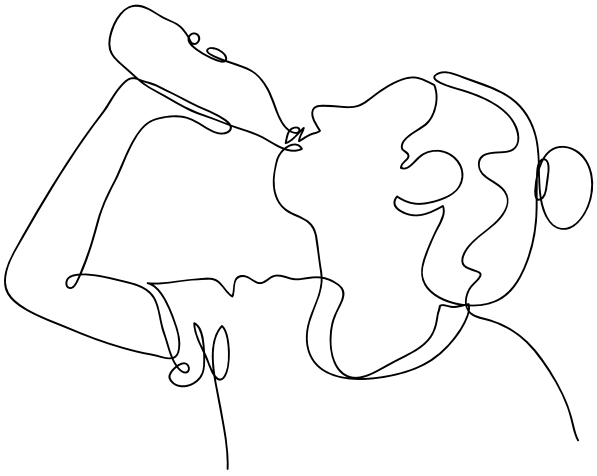
Figure 22

Water end-market composition

In share of total market



Note: Ballast water treatment, a beneficiary of green shipping, is also an attractive niche in the water market that offers a regulatory opportunity independent of infrastructure and water utility spending. However, the ballast water treatment market goes beyond the scope of this report.
Source: RBC Capital Markets estimates, company reports, as of September 2020



See endnotes on page 66.


Pexels / Jack Redgate

Conclusion

In the years ahead, finding solutions to sustainability challenges will likely gain in prominence as the urgency becomes increasingly apparent. Despite the high level of complexity involved in finding solutions to these challenges, it has become clear the time for action is now. Throughout this report, we have described the growing costs of environmental inaction, in terms of both economic growth and human health, and we have detailed the impact environmental factors can have on investors' portfolios. While there is no straightforward, guaranteed, or one-stop solution to environmental challenges, emerging innovations in products and services offer a glimpse of hope for the future of Earth.

To combat rising emissions and a growing population, a coordinated effort across regions, governments, corporations, and investors will be necessary. By directing capital toward solutions and considering environmental factors in their strategies, investors can play a key role in the race to net zero emissions and simultaneously capitalize on the opportunities. More specifically, we see significant growth opportunities across a range of industries including climate-resilient infrastructure enterprises; renewable energy, low emission, electric transport, and digital agriculture solutions; and select fixed income offerings such as green bonds and sustainable municipal bonds. Private market and alternative investments offer additional ways to deploy capital toward climate-friendly investments and innovations.

Despite the daunting challenges we face, there are reasons to be optimistic for the future. In recent years, we have already seen a significant shift in investor sentiment, in government policy, and in the viability of potential solutions. This momentum looks set to continue in the years ahead, and both risks and opportunities bear monitoring as we look to the future.

See endnotes on page 66.

Endnotes

[1] Aon Impact Forecasting, "Weather, Climate & Catastrophe Insight: 2020 Annual Report," https://www.aon.com/global-weather-catastrophe-natural-disasters-costs-climate-change-2020-annual-report/index.html

[2] NOAA National Centers for Environmental Information 2021, "Billion-Dollar Weather and Climate Disasters," https://www.ncdc.noaa.gov/billions/

[3] OECD 2017, "Investing in Climate, Investing in Growth," http://dx.doi.org/10.1787/9789264273528-en

[4] Impossible Foods 2019, "Kids in the Kitchen: Accelerating the shift to a sustainable food system," https://impossiblefoods.com/blog/generational-trends-kids-in-the-kitchen

[5] Allianz Global Wealth Report 2020; Credit Suisse Global Wealth Report 2020; United Nations 2019

[6] World Health Organization 2016, "Ambient Air Pollution: A global assessment of exposure and burden of disease"

[7] World Health Organization 2018, "Ambient (outdoor) air pollution," https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

[8] World Health Organization 2016, World Health Data Platform, accessed via https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/household-air-pollution

[9] World Bank and Institute for Health Metrics and Evaluation 2016, "The Cost of Air Pollution: Strengthening the Economic Case for Action"

[10] Ihab Mikati, Adam F. Benson, Thomas J. Luben, et al., "Disparities in Distribution of Particulate Matter Emission Sources by Race and Poverty Status," *American Journal of Public Health,* 2018

[11] Climate Impact Lab 2020, "Valuing the Global Mortality Consequences of Climate Change: Accounting for Adaptation Costs and Benefits," National Bureau of Economic Research, https://www.nber.org/papers/w27599

[12] Climate Impact Lab 2020, "Valuing the Global Mortality Consequences of Climate Change: Accounting for Adaptation Costs and Benefits," National Bureau of Economic Research, https://www.nber.org/papers/w27599

[13] Joel D. Schwartz, Mihye Lee, Patrick L. Kinney, et al., "Projections of temperature-attributable premature deaths in 209 U.S. cities using a cluster-based Poisson approach," *Environmental Health,* 2015, https://doi.org/10.1186/s12940-015-0071-2

[14] International Labor Organization 2019, "Working on a Hotter Planet,"

[15] Tracy Barreau, David Conway, Karen Haught, et al., "Physical, Mental, and Financial Impacts From Drought in Two California Counties," *American Journal of Public Health,* 2015, https://pubmed.ncbi.nlm.nih.gov/28323464/

[16] WWF Australia 2020, https://www.wwf.org.au/what-we-do/bushfires#gs.up8gz5

[17] International Energy Agency World Energy Outlook 2020, https://www.iea.org/reports/world-energy-outlook-2020/overview-and-key-findings#abstract

[18] Sadie J. Ryan, et al., "Global expansion and redistribution of Aedes-borne virus transmission risk with climate change," *PLOS Neglected Tropical Diseases,* 2019; Morgan Stanley Research

[19] Jochen Hinkel, Daniel Lincke, et al., "Coastal Flood Damage and Adaptation Cost under 21st Century Sea Level Rise," Proceedings of the National Academy of Sciences, 2014

[20] Asian Development Bank 2017, "What does climate change mean for Asia's Future Infrastructure?"

[21] US Global Change Research Program 2018, "Fourth National Climate Assessment," https://nca2018.globalchange.gov/chapter/11/#key-message-1

[22] Various studies, Bandung Institute of Technology, 2018

[23] Gilles Erkens, et al., "Sinking coastal cities," International Association of Hydrological Sciences, 2015

[24] Brookings Institution 2019, 2020, "2020 and beyond: Maintaining the bipartisan narrative on US global development," and "The Climate Crisis, Migration and Refugees"

[25] Simrit Kaur and Harpreet Kaur, "A storm of climate change migration is brewing in South Asia," East Asia Forum, 2018

[26] Deltares 2015, "Sinking cities: An integrated approach towards solutions"

[27] World Economic Forum 2018, "Bangkok is sinking. Here's how a new park can protect the city from flooding"

[28] International Energy Agency (2020), World Energy Outlook 2020, IEA, Paris

[29] World Economic Forum 2017, "Deforestation causes almost as much greenhouse gas emissions as global road travel. Here is how we can help halt it"

[30] Cheikh Mbow, Cynthia Rosenzweig, et al. "Food Security" chapter in "Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems," 2019, https://www.ipcc.ch/site/assets/uploads/2019/11/08_Chapter-5.pdf

[31] OECD 2019, "Enhancing Climate Change Mitigation through Agriculture"

[32] Christian Aldridge, et al., "Global Forest Review," World Resources Institute, 2021

[33] OECD 2019, "Enhancing Climate Change Mitigation through Agriculture"

[34] Food and Agriculture Organization of the United Nations and United Nations Environmental Program 2020, "The State of the World's Forests 2020: Forests, biodiversity and people"

[35] Luca Montanarella, Robert Scholes, Anastasia Brainich, et al. "The IPBES Assessment Report On Land Degradation And Restoration," 2018, https://www.ipbes.net/assessment-reports/ldr

[36] OECD 2019, "Enhancing Climate Change Mitigation through Agriculture"

[37] Celine Herweijer, et al., "Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy," World Economic Forum and PWC, 2020

[38] Andrea Willige, "75% of crops depend on pollinators - they must be protected," World Economic Forum, 2019

[39] Richard Waite and Alex Rudee, "Six Ways the US Can Curb Climate Change and Grow More Food," World Resources Institute, 2020

[40] John Gapper, "How millennials became the world's most powerful consumers," *Financial Times,* 2018

[41] Based on estimates from RBC Capital Markets as of September 2020

[42] Igor A. Shiklomanov, "World Fresh Water Resources" chapter in "Water in Crisis: A Guide to the World's Fresh Water Resources," Peter H. Gleick (editor), Oxford University Press, New York, 1993

[43] Food and Agriculture Organization of the United Nations, Water use. Extracted from: http://www.fao.org/aquastat/en/overview/methodology/water-use/ in 2020

[44] United Nations 2017, https://sdgs.un.org/goals/goal6

[45] Alexander Zehnder, Hong Yang, Roland Schertenleib, "Water issues: the need for action at different levels," *Aquatic Sciences,* 2003

[46] OECD 2016, 2017, "Water, growth and finance," Policy Perspectives, and "The economic case for investment in water security," Roundtable on Financing Water, www.oecd.org/water

[47] OECD 2009, "Managing Water for All: An OECD perspective on pricing and financing – Key message for policy makers," www.oecd.org/water

[48] UNESCO 2020, "The United Nations World Water Development Report 2020: Water and Climate Change"

[49] Several press releases from the City of Cape Town in the years 2017 and 2018

[50] UNESCO 2019, "The United Nations World Water Development Report 2019: Leaving no one behind"

[51] Burek, P., Satoh, Y., Fischer, G., Kahil, M. T., Scherzer, A., Tramberend, S., Nava, L. F., Wada, Y., Eisner, S., Flörke, M., Hanasaki, N., Magnuszewski, P., Cosgrove, B., and Wiberg, D.: Water Futures and Solution - Fast Track Initiative (Final Report), IIASA, Laxenburg, Austria, IIASA Working Paper, 2016

[52] "Sustainability" scenario 20% growth in water demand 2010-2050, "Middle of the Road" scenario 27% growth, and "Regional Rivalry" scenario 33% growth. "Sustainability" scenario: resulting in low challenges with respect to sustainability, mitigation and adaptation. "Middle of the Road" scenario: intermediate challenges. And "Regional Rivalry" scenario: high challenges.

[53] Burek, P., Satoh, Y., Fischer, G., Kahil, M. T., Scherzer, A., Tramberend, S., Nava, L. F., Wada, Y., Eisner, S., Flörke, M., Hanasaki, N., Magnuszewski, P., Cosgrove, B., and Wiberg, D.: Water Futures and Solution - Fast Track Initiative (Final Report), IIASA, Laxenburg, Austria, IIASA Working Paper, 2016

[54] Burek, P., Satoh, Y., Fischer, G., Kahil, M. T., Scherzer, A., Tramberend, S., Nava, L. F., Wada, Y., Eisner, S., Flörke, M., Hanasaki, N., Magnuszewski, P., Cosgrove, B., and Wiberg, D.: Water Futures and Solution - Fast Track Initiative (Final Report), IIASA, Laxenburg, Austria, IIASA Working Paper, 2016

* #TOGETHERBAND ambassador

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