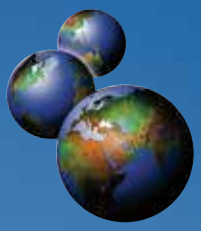
UNEP

GEO-5 for Business

Impacts of a Changing Environment on the Corporate Sector



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UNEP

Green Light Group
Environmental Consulting

Sust

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Foreword

Environmental change, in large part driven by humanity's demand for resources, rising lifestyles and growing global population, is accelerating and generating new and emerging challenges but also opportunities for business.

Companies that face up to these realities are likely to be the ones that thrive and remain competitive in a rapidly changing world where factors such as climate change and dwindling availability of natural resources like water will shape future profit and loss and drive new markets.

This new report, GEO-5 for Business, is based on the flagship assessment by the UN Environment Programme (UNEP), the Global Environment Outlook 5, which was launched in advance of the Rio+20 Summit.

GEO-5 for Business outlines current and future impacts of environmental trends across a range of sectors from construction to food. It dovetails with other assessments such as those by the UNEP-hosted International Resource Panel that estimate consumption of natural resources will triple by 2050 unless urgent action is taken to decouple economic growth from natural resource use.

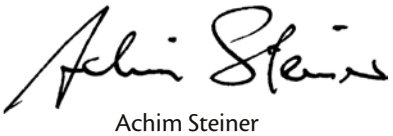
These trends are likely to not only impact and influence markets but also trigger technological innovation and change while stimulating regulatory and policy developments nationally and internationally, which in turn represent opportunities for business in respect to new kinds of goods and services.

Meanwhile as policy-makers, the public and investors become ever more aware of environmental change, they are likely to demand increasing transparency and more comprehensive corporate sustainability reporting – indeed this new push for sustainability reporting was among a range of outcomes from Rio+20.

GEO-5 for Business notes that not all opportunities glimpsed today may be opportunities tomorrow – as the Arctic melts many oil and gas companies are scrambling to exploit the opportunity, but may expose themselves to a range of other risks in a fragile environment.

GEO-5 for Business recommends that businesses conduct a deeper, company-specific analysis, taking a life-cycle approach using this report as a framework and guide.

Those who succeed may find that they not only can use the trends to their advantage, but can generate real and ever more transformative solutions to challenges already arising from a rapidly changing environment in a rapidly changing world.



Achim Steiner
United Nations Under-Secretary General and Executive Director
United Nations Environment Programme

Executive Summary

Global environmental trends are creating new risks and new opportunities for businesses in every industry. Indeed the transition to a green economy, now in its early stages, will open up great opportunities for companies that understand the implications of these trends and account for them in their planning and business strategy. Conversely, companies that fail to understand the changes, or that act too slowly, will put value at risk.

GEO-5 for Business is written for business leaders who are responsible for ensuring that risks and opportunities are understood, addressed, and turned into long-term competitive advantage for their companies. The report assesses the operational, market, reputational, and policy implications of environmental trends on ten business sectors:

- Building and construction
- Chemicals
- Electric power
- Extractives
- Finance
- Food and beverage
- Healthcare
- Information and communication technology
- Tourism
- Transportation

The report describes business risks and opportunities based on information derived from existing science, business, policy, and other literature. It also includes brief real-world examples that illustrate the nature of some of these risks and opportunities. The report contains extensive citations throughout, allowing readers to easily access source documents that provide further details on specific trends and impacts.

GEO-5 for Business builds on the findings of UNEP's fifth Global Environment Outlook (GEO-5) report, released in June 2012. GEO-5 assessed the current state and trends of the global environment, in which population growth, economic development, urbanization, and globalization are driving degradation across numerous environmental indicators. Out of 90 environmental goals and objectives assessed in GEO-5, significant progress could only be shown for four. Chapter 2 of the report briefly summarizes the drivers and trends described in GEO-5. Both the specific trends in GEO-5 and the broader picture of decline have significant implications for companies around the world, regardless of size or sector, some of which are reflected in the following table.

Environmental Trend from GEO 5	Key Implications for Business
Greenhouse gases – Greenhouse gas emissions are projected to double in the next 50 years. Such growth may lead to global average surface temperature increases of 3°C to 6°C by the end of the century [GEO-5, pp.16, 20, 36, 429]	Market shifts favoring lower-carbon products; operational and supply chain disruptions; higher cost of energy, food, and other commodities; shifting production and transportation patterns to adapt to local conditions
Severe Weather – There was a 230 percent rise in the number of flood disasters and a 38 percent rise in drought disasters occurring between the 1980s and the 2000s [GEO-5, pp.107-108]	Operational and supply chain disruption; increased cost of operations and materials; damage to shared public infrastructure; increased demand for reconstruction services
Land Conversion – There is a projected increase in land requirements for urban uses by 100-200 million hectares over the next 40 years [GEO-5, p.77]	New and growing markets from urban expansion; restricted access to land-based resources; loss of ecosystem services; competition for arable land; increasing pressure to protect critical natural resources
Water Availability – Global water withdrawals have tripled over the last 50 years to meet agricultural, industrial, and domestic demands [GEO-5, pp.102-104, 436]	New markets for water-efficient products; constraints on growth due to water scarcity; operational and supply chain disruptions; conflicts with other stakeholders over limited supply; increasing cost of water
Water Pollution – Persistent toxic chemical pollutants, now found in 90 percent of water bodies, continue to accumulate in aquatic systems [GEO-5, p.112]	Increased demand for pollution control devices and systems; increased cost of water treatment; stricter water quality regulations; increased demand for healthcare services to treat health impacts
Biodiversity – Critical habitat such as forests, wetlands, and drylands continue to decline. 13 million hectares of forest were lost between 2000 and 2010. Species extinction is expected to continue at a high rate through the 21st century [GEO-5, pp.71-72, 140, 158]	Increased market, reputational, and regulatory pressure to reduce biodiversity impacts; increased cost and reduced availability of scarce resources; reduced opportunity for new product breakthroughs; limitations on access to land
Chemical Exposure – More than 248,000 chemical products are commercially available, but there is a lack of data on their individual and synergistic effects on health and the environment [GEO-5, pp.170, 172-173, 185]	Market shifts toward "greener" products; product use restrictions; regulatory, customer, and public pressure for greater transparency
Waste – Materials are increasingly produced in one region, used in another, and managed as waste in a third. The fastest growing waste stream in the world, estimated at 20-50 million tonnes per year, is e-waste, which has hazardous substances as well as strategic metals that can be recovered [GEO-5, pp.175, 184]	Growing market opportunity to recover/re-use e-waste; increasing regulatory and customer pressure to reduce/manage waste; reputational damage resulting from uncontrolled waste

This is the world that business must navigate, today and into the future. Without dramatic and unexpected shifts in the drivers of these trends, we can expect that environmental pressures such as those noted above will increase throughout the foreseeable future, causing major changes not only in physical landscapes, but in social, political, and business landscapes as well.

The specific implications of these environmental trends for business are described in greater detail in Chapter 3. The table below provides a brief summary of some of the major risks and opportunities for each of the sectors assessed in the report. Note that some of the identified business opportunities may have negative impacts on the environment; the sole intent of the report is to identify them, not to assess their desirability.

Environmental pressures will increase throughout the foreseeable future, causing major changes not only in physical landscapes, but in social, political, and business landscapes as well.

Risks	Opportunities
Building and Construction (section 3.1)	
• Constrained availability and increased cost of materials • Impacts of changing weather patterns on construction schedules/ costs • Limits on development opportunities in water-scarce and high-biodiversity areas • Shifts in skills and knowledge required to meet the changing market • Stricter limits on waste and pollution	• Increased market demand for sustainable infrastructure and buildings, storm-damage repair/reconstruction, energy efficiency retrofits and technologies, and climate-resilient structures • Increased demand for renewable, recycled, and resource-efficient materials and processes • Increased market value of green buildings • Increased demand for workforce skilled in sustainable design and construction • Reputational benefit associated with green design and construction certifications
Chemicals (section 3.2)	
• Increased costs for fossil fuel-based energy and feedstocks • Higher water costs and constrained operations due to increasing water scarcity • Business interruption related to extreme weather or water scarcity • Product use restrictions or phase-outs • Regulatory or market-driven reductions in demand for some chemical products • Stricter regulatory limits on air emissions and water discharges • Reputational damage due to conflicts with communities over resources or pollution • Increased pressure to disclose data on the health and environmental effects of chemicals	• Increased demand for components of energy efficiency or renewable energy technologies, water treatment technologies, and more sustainable agricultural inputs • Increased demand for green chemistry products and chemical leasing business models • New market opportunities for products that can substitute for restricted or phased-out products • Reputational benefit associated with green chemistry
Electric Power (section 3.3)	
• Constrained availability and increased cost of fossil fuel-based stocks due to climate change policies • Reduced demand for carbon-intensive electricity • Reduced grid reliability due to increased peak demand • Infrastructure damage due to extreme weather • Limits on some electricity generation due to water scarcity and potential conflicts with competing users for limited water supplies • Stricter regulatory limits on air emissions and water discharges • Threats to the current utility business model from regulatory and legislative actions • Stricter legislation/regulations on greenhouse gas emissions, air quality, wastewater effluent discharges, and siting of power plants	• Increased demand for electricity for building cooling and powering electric vehicles • Increased demand for low-carbon and renewable electricity • Potential new business models opened up by regulatory actions • Increased demand for smart-grid technologies, energy storage, and energy efficiency services
Extractives (section 3.4)	
• Increased cost of fossil fuel-based energy for some mining operations • Infrastructure damage and business interruption due to extreme weather • Business interruption due to water scarcity • Limits on access to resources in water-scarce or high-biodiversity areas • Stricter regulatory limits on air emissions and water discharges • Increased liability risks and costs of decommissioning due to changing weather patterns • Stranded assets (e.g., oil and coal reserves) if strong carbon constraints or costs are imposed • Reduced demand for virgin minerals in favor of recycled materials • Reputational damage and potential loss of social license to operate for companies seen as major contributors to climate change or major water users in water-scarce areas	• Increased demand for certain minerals and materials used in renewable energy, energy efficiency, air pollution control, and water purification technologies • Increased market for cleaner fuels • Increased market for recycled and more sustainable minerals • Warmer temperatures opening previously inaccessible or uneconomical areas for exploration and extraction • Reputational advantage for companies seen as part of the solution to climate change • New markets for carbon capture/storage and other technologies to reduce carbon emissions from fossil fuel combustion
Finance (section 3.5)	
• Increased uncertainty of underwriting by insurance companies due to changing weather patterns • Increased cost of insurance claims resulting from more severe weather events • Increased pressure on lenders and investors to improve consideration and disclosure of client companies' impacts on and from environmental trends • Potential long-term systemic risks to financial markets from "unburnable carbon" if strong carbon constraints or costs are imposed • Reduced ability of lenders' clients with stranded assets (related to climate change or water scarcity) to re-pay loans • Reputational damage for companies providing lending for environmentally damaging activities	• Increased demand for property insurance coverage • New markets for financial mechanisms that reduce risks or create positive returns/lower capital costs for more sustainable products and services • Increased demand for capital financing for environmental solutions • Increased creation of attractive green economy investment opportunities • New or expanded markets and investment in products that incorporate environmental criteria and/or targeted solutions for issues such as climate change • Expanded markets for insurance products that encourage the spread of more energy-efficient homes and buildings and renewable energy technologies

Risks	Opportunities
Food and Beverage (section 3.6)	
• Changes in availability, quality, price, and sources of agricultural products due to climate change and other environmental changes • Increased cost of fossil fuel-based energy • Reduced crop yields due to water scarcity • Conflicts among different users of limited water resources • Increased competition for arable land • Depletion of seafood stocks • Increased consumer and regulatory pressure to reduce environmental impacts of meat production and of chemicals and fertilizers	• New markets for alternative supplies or more climate-resilient food varieties • Opportunities for businesses in new agricultural growing zones • Expanded markets for organic foods and sustainable food production • Reputational benefits from sustainable food product certifications
Healthcare (section 3.7)	
• Increased cost of fossil fuel-based energy for healthcare facilities • Increased pressure to improve sustainability, including keeping medicines out of the waste stream, reducing energy use, and reducing use of toxic substances in cleaning products • Increased loss of natural compounds that are traditional remedies and active ingredients in pharmaceuticals	• Increased demand for treatment of illnesses resulting from environmental changes and exposure to pollution (e.g., respiratory and cardiovascular illness, water-borne and vector-borne diseases) • New markets for medicines that do not require clean water or controlled temperature storage
Information and Communication Technology (section 3.8)	
• Increased cost of fossil fuel-based energy (e.g., for datacenters) • Production interruption or limitations due to limited water availability • Supply chain disruption due to extreme weather and other environmental factors • Increased costs due to regulatory or customer pressure to reduce e-waste • Regulatory limitations on releases of greenhouse gases during product manufacture, use, and end-of-life • Reputational damage due to uncontrolled e-waste or environmental impacts of suppliers	• New and expanded markets for products that enable environmental improvements in other industries (e.g. smart buildings, integrated transportation, automated manufacturing) • Expanded markets to displace traditional goods and services with virtual ones • Expanded markets for collecting and processing environmental data • Reputational benefit to companies recognized as contributing to solving environmental challenges such as climate change, water quality/availability, and deforestation
Tourism (section 3.9)	
• Increased cost of fossil fuel-based energy • Increased operating costs due to warmer average temperatures and declining availability of local resources • Business interruption, property damage, and travel delays due to extreme weather events • Limits on available activities due to water scarcity, ecosystem changes, and concerns for biodiversity • Reduced desirability of some destinations due to environmental changes • Stricter regulations on some practices (e.g., fishing on coral reefs, development in coastal mangroves) • Increasing conflicts with local communities related to scarce resources	• Improved desirability of some destinations due to environmental changes • Increased demand for nature-based tourism, ecotourism, and agro-tourism • Reputational benefits and increased demand for companies/ destinations perceived as environmentally responsible
Transportation (section 3.10)	
• Increased cost of fuel for operation of vehicles • Infrastructure damage and supply chain disruption due to extreme weather and other environmental factors • Increased cost or limited production due to water scarcity in some manufacturing locations • Increased regulations to limit greenhouse gas emissions and control waste streams	• Increased demand by business customers to reduce logistical footprint and costs • New and expanded markets for low-carbon and cleaner transportation options (e.g., vehicles, fuels) • New freight routes resulting from declining sea ice

In Chapter 4, the report concludes by suggesting a path forward for business leaders seeking to understand and address the risks and opportunities posed by environmental trends. That path includes:

- Conducting a deeper, company-specific analysis, taking a life-cycle approach and using the report as a framework and guide
- Continuing to mitigate the impacts of the business on the environment
- Thinking strategically about how the business must change to reflect changes in the global and local environment
- Reporting to stakeholders (investors, employees, customers, communities, NGOs, and others) on the company's impacts on the environment, the risks and opportunities posed by environmental trends, and the strategies to address them
- Working with policy-makers to craft public policies that encourage sustainable business practices
- Collaborating with others to create powerful solutions to challenges created by changes in the environment.

GEO-5 for Business makes clear that business value is at stake due to changes in the state of the world's environment. The risks are high, but the opportunities are abundant. Assessing the implications of environmental trends across the life cycle and accounting for them in planning and business models will improve companies' competitiveness, reduce environmental degradation, and enhance human well-being.

1. Introduction

> "The current economic system, built on the idea of perpetual growth, sits uneasily within an ecological system that is bound by biophysical limits."
>
> UNEP's GEO-5

Understanding environmental trends is of critical importance to business leaders. Just as social, economic, market, and technological trends – and company responses to those trends – influence the success of businesses, so too do environmental trends. Current and future environmental conditions affect operating costs, raw material availability, regulations, consumer preferences, reputational considerations, and demand for products.

The need to understand environmental trends is not new. Indeed, the availability of fertile soil, clean water, wildlife and its habitat, and a stable climate has influenced human settlement and development for millennia. Since the Industrial Revolution, however, pressure on the environment and natural resources – and the services they provide – has accelerated dramatically. The pressure has been driven primarily by the combination of human population growth, rapidly increasing levels of prosperity and consumption, and the intensification of industrial activity. Over the last 50 years in particular, environmental degradation has expanded from a local scale to a global scale. The consequences of this acceleration are clear: while economic growth and prosperity have improved the quality of life for billions of people, they are also destabilizing the climate and degrading the world's natural resources – the foundations on which future prosperity depends.

The ramifications of these changes on business are sweeping. For instance, damage from climate change impacts (particularly over the long term) could have enormous effects on the global economy and the environmental support systems on which all businesses (and human societies) rely, especially if average global surface temperatures warm more than 2°C, as seems likely without major policy shifts and transformative action from governments, businesses, and others.[1] Similarly, climate impacts, resource scarcity, and resulting changes in population migration may have broader systems-level effects, destabilizing countries and thus the political and socioeconomic contexts in which businesses operate.[2]

Perpetual growth is the operating principle, reinforced by our current economic and political systems, on which many of the world's business leaders, policy-makers, and investors make decisions every day. As a result, the gap between our current level of consumption and what the global environment can support on a sustained basis continues to grow.

The science is clear: we are approaching, and in some cases surpassing, the limits of our planet's resources and carrying capacity. Scientific experts warn that many of these impacts may become permanent in human timescales if action to alleviate pressures does not occur immediately.[3]

The business need is also clear: assessing environmental trends across the life cycle and understanding their impacts on operations, markets, policy, and reputation is essential for companies to effectively manage risk, capture opportunities, and create long-term competitive advantage.

The science is clear: we are approaching, and in some cases surpassing, the limits of our planet's resources and carrying capacity.

UNEP's Global Environment Outlook

Since 1997, the United Nations Environment Programme (UNEP) has produced five Global Environment Outlook (GEO) assessment reports. The main goal of the GEO series is to keep governments and other stakeholders informed of the state, trends, and outlook of the global environment, in light of the continuing need for up-to-date, scientifically credible, policy-relevant information on environmental change worldwide.

The fifth Global Environment Outlook – GEO-5 – was launched in June 2012 on the eve of the second United Nations Conference on Sustainable Development (or Rio+20) in Rio de Janeiro. It integrates inputs from hundreds of scientists and policy experts and is organized in three parts: (1) state and trends of the global environment, including drivers of change; (2) policy options from all regions of the world that have proven successful in advancing internationally agreed goals, and (3) opportunities for a global response.

UNEP has also published several supplements to GEO-5, including the GEO-5 Summary for Policy Makers, GEO-5 for Local Government, Keeping Track of our Environment, Measuring Progress, and GEO-5 for Youth – available at http://www.unep.org/geo.

GEO-5 for Business

This report – GEO-5 for Business – adds an important contribution to the suite of GEO-5 supplements. It is written especially for business leaders. By addressing the needs of business, UNEP hopes to begin a dialogue that will span future GEO assessment cycles and provide opportunities for partnership.

GEO-5 for Business pulls the most important conclusions from the comprehensive GEO-5 report and maps their relevance to specific business sectors. The report includes two main components:

- **A summary of environmental trends and drivers.** Chapter 2 provides a brief snapshot of some of the key messages from GEO-5. While it is recognized that there are numerous other sources of scientific information on environmental trends, this chapter is limited to the content of GEO-5. Various other sources are referenced throughout subsequent chapters.
- **Sector-specific implications of environmental trends and drivers.** Chapter 3 describes the impacts of environmental trends and drivers on ten business sectors, focusing on implications related to (a) operations (including supply chains), (b) markets, (c) public policy, and (d) reputation/brand value. Brief real-world examples are provided to illustrate the implications of environmental trends for businesses.

While many of the examples cited in this report refer to large multinational companies, GEO-5 for Business is just as relevant to small and medium-size companies that operate directly in the ten sectors analyzed, as well as in the broader value chains of those sectors. In addition, the report is equally relevant to companies in both developed and developing countries.

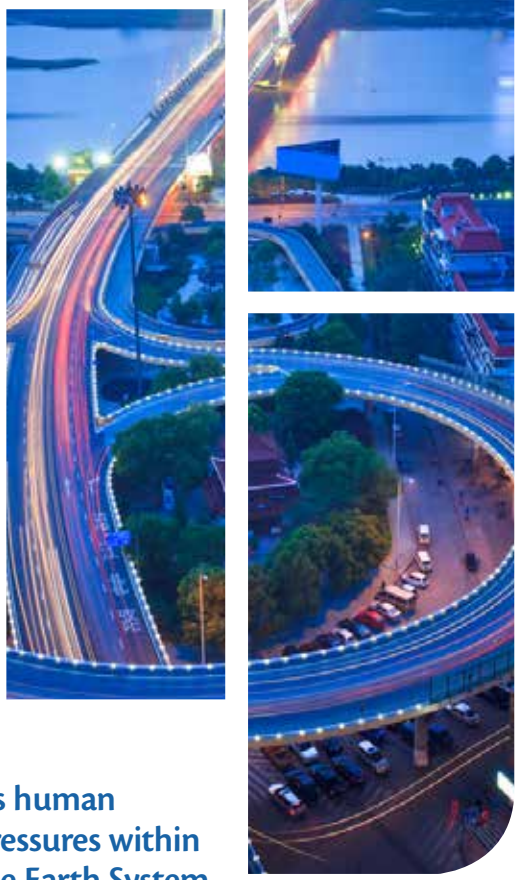
GEO-5 for Business focuses on the impacts of environmental trends on business, rather than the impacts of business on environmental trends. This focus is not meant to imply that businesses should not continue efforts to mitigate their environmental impacts; rather, it is intended to highlight that businesses also need to assess their risks and opportunities – and adapt for a different future.

This report describes how environmental trends will likely impact specific industries. While it provides valuable guidance, it is not a substitute for a robust, company-specific analysis of risks and opportunities facing any individual company. Product mix, geography, size, customer base, and other factors vary from company to company, and all affect the materiality of individual trends and the appropriate responses to those trends.

While many of the examples refer to large multinational companies, GEO-5 for Business is just as relevant to small and medium-size companies. The report is equally relevant to companies in both developed and developing countries.

Physical, social, political, and business landscapes are changing rapidly. How companies assess the risks and opportunities and respond to the changing landscapes will shape how successful they will be in the future.

2. Key Findings from GEO-5 Concerning the State and Trends of the Environment



> "As human pressures within the Earth System increase, several critical thresholds are approaching or have been exceeded, beyond which abrupt and non-linear changes to the life-support functions of the planet could occur"
>
> UNEP's GEO-5

The fifth edition of the Global Environment Outlook (GEO-5) provides a comprehensive update of the state and trends of the global environment in five domains (atmosphere, land, water, biodiversity, and chemicals and waste), describes the drivers behind them, and assesses progress towards achieving select internationally agreed goals.

2.1 Key Drivers

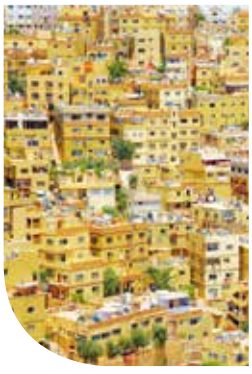
The environmental trends described in GEO-5 are largely a result of two key linked drivers:

- **Population Growth** – Over the last 100 years, the Earth's population has quadrupled to 7 billion people. Population is expected to reach 10 billion by 2100, with most of the world's net population growth by 2050 projected to occur in the world's poorest cities.[4]
- **Economic Development** –Global economic output has increased roughly 20-fold over the last 100 years and is expected to continue to increase throughout this century. While consumption trends appear to have stabilized in developed countries, emerging economies are seeing rising per-person resource use and associated environmental impacts, and the less developed countries are just beginning the transition towards higher consumption levels.[5]

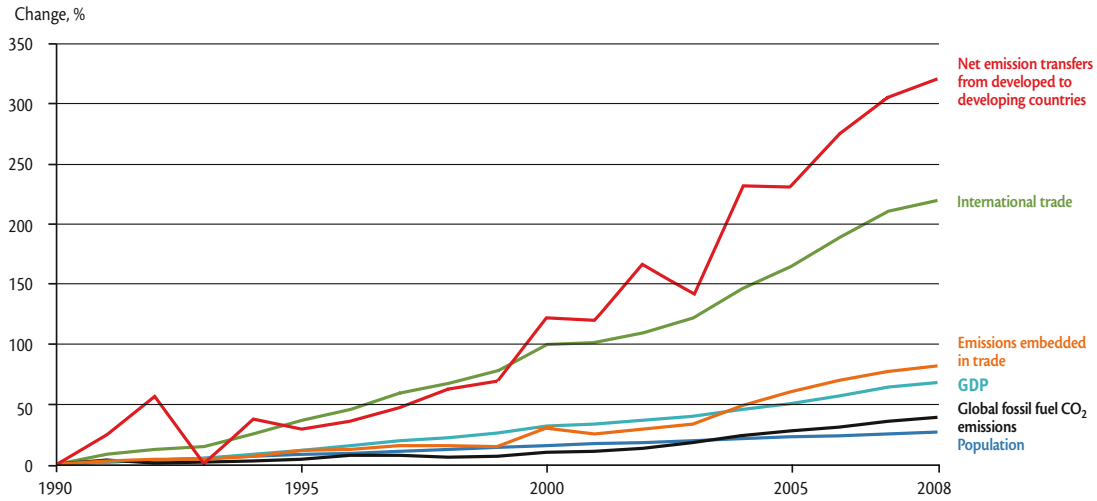
These drivers are manifested in four fundamental ways:

- **Energy Consumption** – Global energy consumption is expected to increase by a factor of three over the 21st century. The global rate of growth in primary energy consumption is expected to decrease in the future, however, due to an assumed leveling of population growth and improved energy efficiency.[6]
- **Urbanization** – Urban areas now house half the world's population, use two-thirds of global energy, and produce 70 percent of global carbon emissions.[7]
- **Globalization** – International trade has grown 12 percent per year since 1990.[8]
- **Demand for Transport** – The number of motor vehicles in the world is growing much faster than the number of people and is expected to grow even further as incomes increase.[9]

The scale, spread, and rate of change of global drivers are without precedent and are pushing environmental systems to destabilizing limits.[10]



Growth in population, GDP, trade and CO_2 emissions, 1990–2008



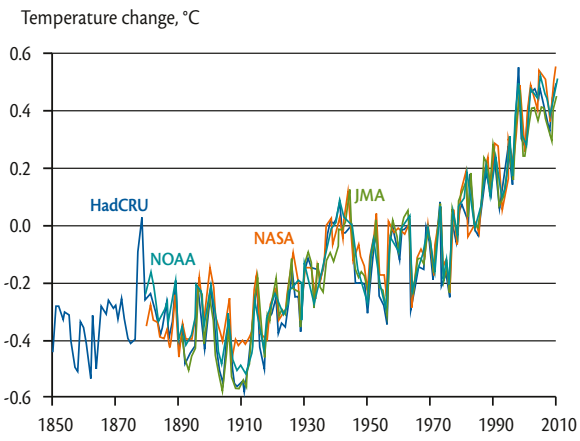
Source: Peters, G.P., Minx, J.C., Weber, C.L. and Edenhofer, O. (2011). Growth in emission transfers via international trade from 1990 to 2008. *Proceedings of the National Academy of Sciences of the United States of America* 108(21), 8903–8908 (GEO-5 p.19)

2.2 Environmental Trends

GEO-5 assessed the state and trends of the global environment in relation to achieving internationally agreed goals. Out of 90 environmental goals and objectives assessed in GEO-5, significant progress could only be shown for four, while progress could not even be determined for 14 others because data were lacking.[11]

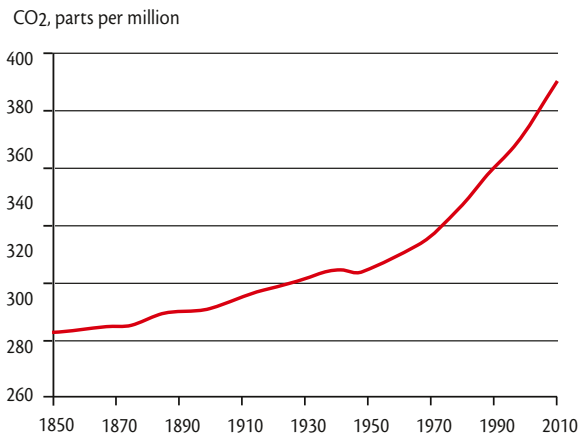
Atmosphere

- Atmospheric concentrations of **greenhouse gases** continue to increase. Without major policy shifts, greenhouse gas emissions are projected to roughly double in the next 50 years, with emissions growth coming primarily from developing countries. Such growth may lead to global average surface temperature increases of 3°C to 6°C by the end of the century. Taking action to reduce short-lived climate pollutants such as methane, black carbon, tropospheric ozone precursors, and some hydrofluorocarbons (HFCs) – which remain in the atmosphere for much less time than carbon dioxide – could help slow the rate of warming within the first half of this century.[12]
- The manifestations of **climate change** are becoming clearer. The years 2000–2009 were the warmest decade on record; the greatest warming occurred at high latitudes. Arctic sea ice cover has decreased dramatically. The Greenland and Antarctic ice sheets show rapidly increasing melt rates. The probability of extreme summer heat, including heat waves, will likely increase by a factor of 5-10 within the next 40 years. Climate impacts are expected to expand arid regions in the sub-tropics, increase damage to low-lying areas from sea-level rise, and increase the frequency and intensity of extreme weather events around the globe.[13]
- Much of the developed world has successfully reduced concentrations of **particulate matter (PM) and sulfur and nitrogen compounds**, but concern remains high elsewhere.[14] Sulfur dioxide, nitrogen oxides, and PM emissions are expected to decline further in Europe and North America by mid-century but increase in Asia and other developing regions.[15]
- Concentrations of **surface ozone**, which harms human health and vegetation, have similarly been declining in Europe and North America but increasing in Asia.[16]
- **Ozone-depleting substances** in the stratosphere have declined 31 percent at mid-latitudes and 17 percent in the Antarctic from a 1994 peak. Recovery of the ozone layer is expected by mid-century.[17]
- Most countries have phased out **lead** in fuel since 2002, and studies worldwide show a strong correlation between decreased use of lead in fuel and reductions of lead in blood. The complete global elimination of lead in fuel is expected within a few years.[18]



Note: 0 = 1961–1990 global mean

Source: NOAA NCDC; NASA GISS; Hadley Climatic Research Unit at the University of East Anglia (HadCRU); Japan Meteorological Agency (JMA) (GEO-5 p. 37)

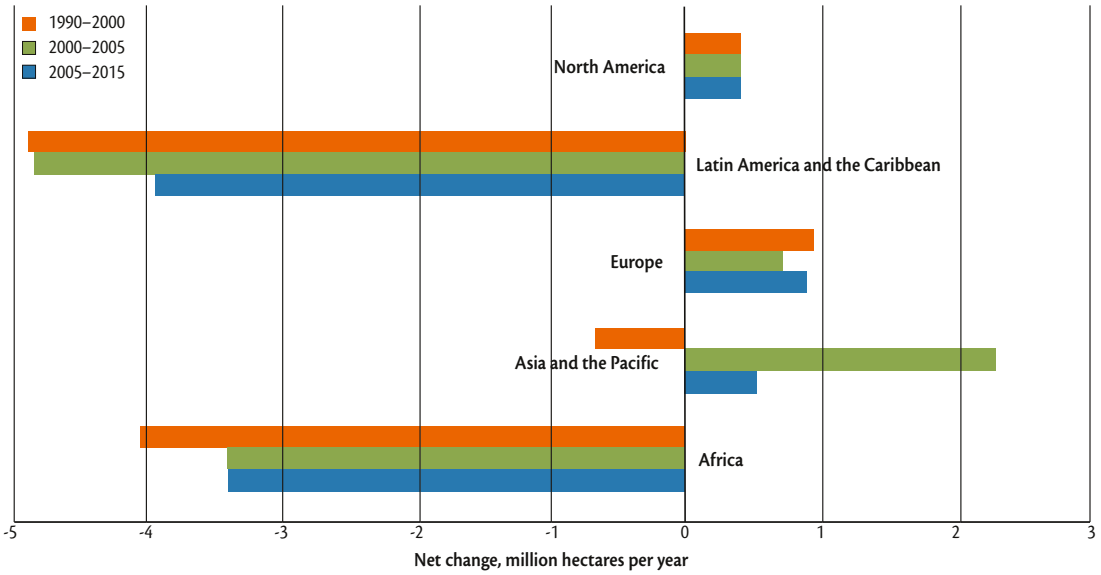


Source: Scripps Institute of Oceanography, NOAA (GEO-5 p. 37)

Land

- Potentially 100-200 million hectares of land are projected to be **converted for urban uses** over the next 40 years.[19]
- Global annual **forest loss** decreased from 16 million hectares in the 1990s to approximately 13 million hectares between 2000 and 2010. Some countries that suffered extensive deforestation in the 1990s, including Brazil and Indonesia, have significantly reduced their rates of forest loss, while less developed nations in Latin America and Africa continue to experience high rates of loss.[20]
- Globally, **coastal wetlands** continue to decline by more than 100,000 hectares (over 0.7 percent) per year, though that rate of loss has slowed relative to the 1 percent per year of the 1980s.[21] Pressure on wetlands is likely to continue or increase due to demand for agricultural land and urban expansion.[22]
- Agricultural productivity in **drylands** is continuing to decrease due to desertification and drought – about 4-10% of dryland productivity is lost each year because of degradation.[23]
- **Arctic permafrost** temperatures have already risen by up to 2°C over the past two to three decades, and up to 90 percent of near-surface permafrost is expected to disappear due to thawing by 2100.[24]

Change in forest area by region, 1990–2010

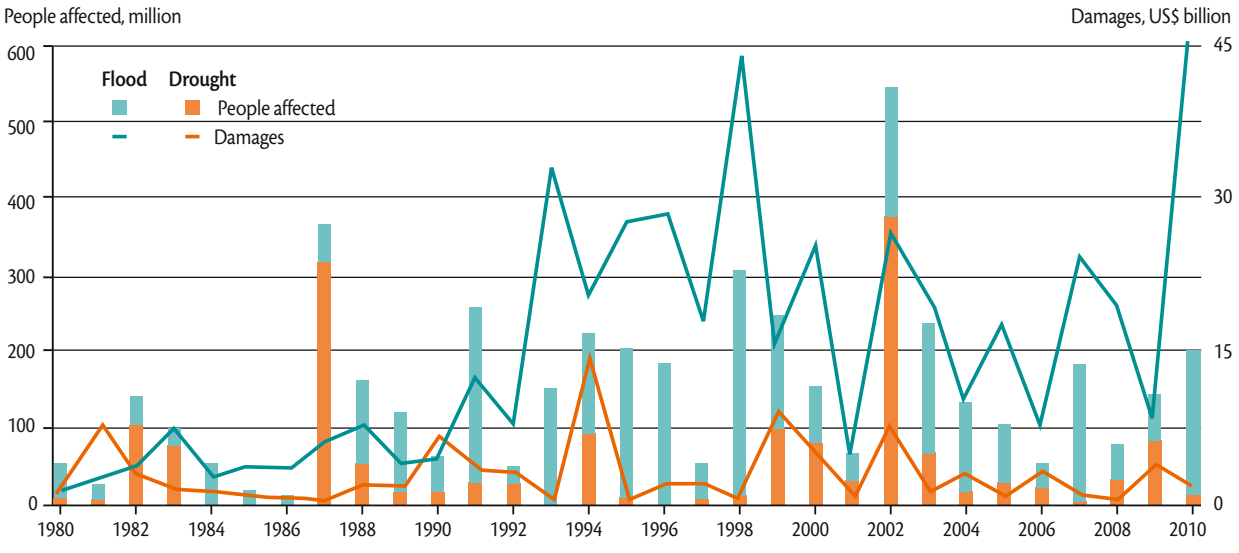


Sources: *Keeping Track of our Changing Environment: from Rio to Rio+20 (1992–2012).* United Nations Environment Programme, Nairobi; *Global Forest Resources Assessment 2010.* FAO Forestry Paper No. 163. Food and Agriculture Organization of the United Nations, Rome. (GEO-5 p. 72)

Water

- More than 2 billion people currently live in **water-stressed areas** (mostly in Asia), and that figure is expected to rise substantially (e.g., fourfold growth in Africa) due to population growth, increased water use, and climate change.[25]
- Global **water withdrawals** (from groundwater and surface water) have tripled over the last 50 years. Agricultural, industrial, and domestic water withdrawals have all steadily increased. Most projections of water demand and water withdrawals through 2050 indicate a large global net increase (with significant regional variations).[26]
- Between the 1980s and the 2000s, the number of **flood disasters and drought disasters** increased 230 percent and 38 percent respectively, causing economic losses of billions of dollars.[27]
- Higher **precipitation intensity** is forecast for the northern hemisphere and equatorial areas, while many already arid and semi-arid areas are expected to get drier. Globally, heavy precipitation is projected to increase by about 7 percent per degree (Celsius) of temperature rise in the 21st century.[28]
- **Freshwater and marine water quality** are compromised. Groundwater around the world is threatened by pollution from agricultural, industrial, extractive, and urban areas. Microbial pathogens are often the most pressing water quality issue in many developing countries. Eutrophication (from excessive nutrient pollution) is also pervasive, and at least 169 coastal areas around the world are considered hypoxic. Persistent toxic chemical pollutants are now found in 90 percent of water bodies and continue to accumulate. Pharmaceuticals and personal care products often enter water systems after use, with largely unknown long-term biological risks to aquatic organisms and humans.[29]
- **Sea level rise**, caused by ocean thermal expansion and melting glaciers and ice sheets, is increasing. Measurements from 1993 to 2008 indicate that sea levels are already rising twice as fast as in previous decades and are exceeding the rise predicted by climate models.[30]
- The rapid growth of atmospheric CO_2 concentrations is associated with similarly rapid increases in **ocean acidification**, which affects marine organisms, particularly those with carbonate shells and skeletons.[31]

People affected by and damages associated with floods and droughts, 1980–2010



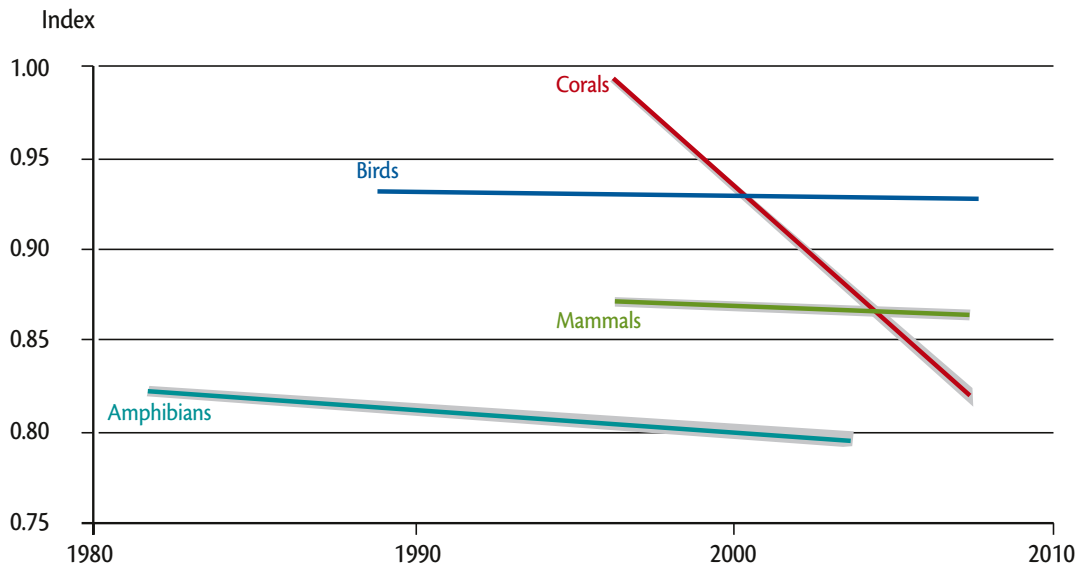
Note: The costs of the large floods in Thailand and Pakistan in 2011 are not included here.

Source: EM-DAT: The OFDA/CRED *International Disaster Database.* Université Catholique de Louvain, Brussels. (GEO-5 p. 107)

Biodiversity

- The world lost 20 percent of its **seagrass and mangrove habitats** since 1970 and 1980, respectively.[32]
- In the 20th century, **wetlands** suffered a 50 percent global loss – and 95 percent in some regions.[33]
- **Coral reefs** globally have declined by 38 percent since 1980, and tropical coral reefs may experience rapid contraction by 2050.[34]
- Two-thirds of the world's largest **rivers** are now moderately to severely fragmented by dams and reservoirs.[35]
- The proportion of **marine fish stocks** that are overexploited, depleted, or recovering from depletion rose from 10 percent in 1974 to 32 percent in 2008.[36]
- IUCN Red List Indices for mammals, birds, amphibians, and corals show that over recent decades considerably higher numbers of species have become more threatened with **extinction** than have become less threatened.[37] Most future scenarios of biodiversity change project continuing high levels of population and species extinctions, loss of habitats, and changes in the distribution and abundance of species and biomes over the 21st century.[38]
- **Protected areas** have expanded over the past 20 years in both number and area. Currently almost 13 percent of the planet's terrestrial area and about 1.5 percent of marine areas are under some degree of protection, though many important sites for biodiversity are not protected.[39]

Red List Indices of species survival for all species of birds, mammals, amphibians and corals, 1980–2010



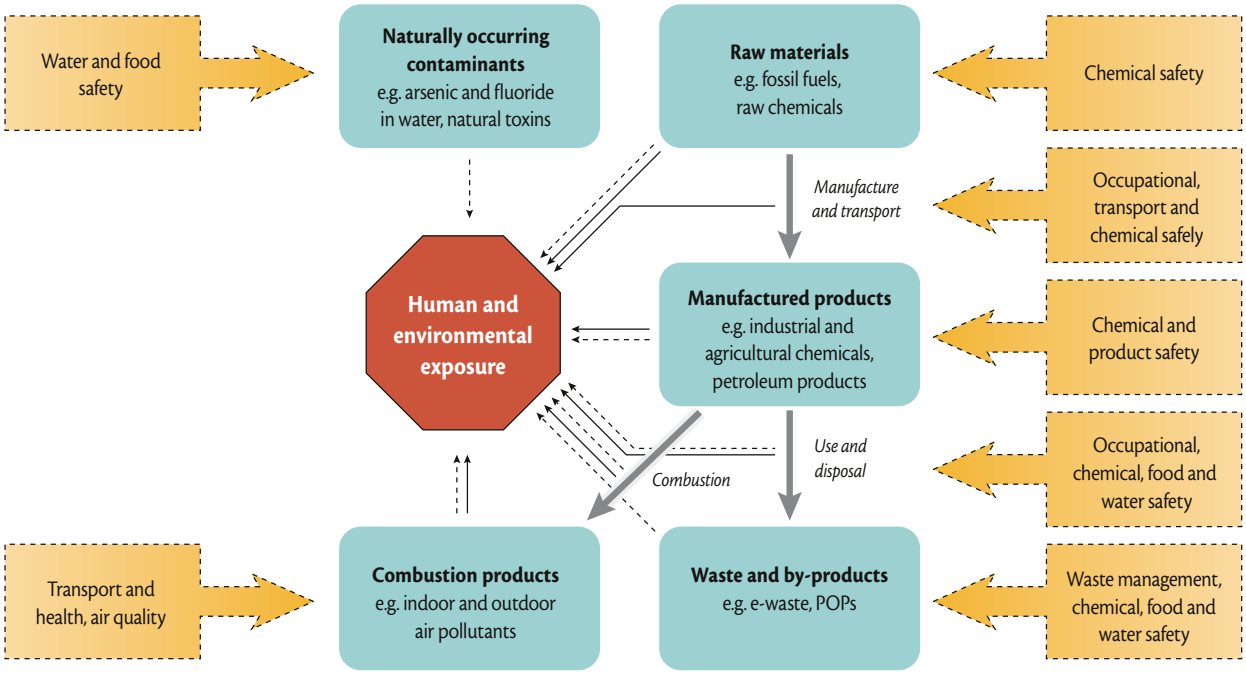
Note: Shaded areas show 95 per cent confidence intervals. The numbers of data-sufficient extant species in year of first assessment were: 9 785 birds, 4 555 mammals, 4 416 amphibians and 704 corals (warm water reef-building species only). An index of 1 equates to all species being classified as Least Concern while an index of 0 equates to all species being classified as Extinct

Source: Adapted from Vié et al. 2009 (GEO-5 p. 145)
Vié, J.-C., Hilton-Taylor, C. and Stuart, S.N. (eds.) (2009). Wildlife in a Changing World. An Analysis of the 2008 IUCN Red List of Threatened Species. International Union for Conservation of Nature, Gland

Chemicals and Waste

- More than 248,000 **chemical products** are commercially available. Humans and ecosystems are exposed to chemicals throughout the chemical life-cycle, including chemical production, use, and disposal, but scarce data makes it difficult to document the extent of the risk posed to human health and the environment from individual chemicals and chemical "cocktails". A variety of initiatives and regulations are working to fill some of these knowledge gaps.[40]
- **Chemical consumption** is growing much faster in developing countries than in developed countries. Some data show that developed countries are reducing some types of chemical use (e.g., pesticides, ozone-depleting substances).[41]
- Due to globalization, materials may be produced in one region, used in another, and managed as **waste** in a third. The fastest growing waste stream in the world is e-waste (i.e., obsolete electrical and electronic products), estimated at 20-50 million tonnes per year.[42]

Life cycle analysis of chemicals



Note: Dashed lines are management options; solid lines correspond to the life cycle.

Source: Adapted from Prüss-Ustün et al. 2011 (GEO-5- p. 176)
Prüss-Ustün, A., Vickers, C., Haefliger, P. and Bertollini, R. (2011). Knowns and unknowns on burden of disease due to chemicals: a systematic review. Environmental Health 10, 9–24

3. Sector-Specific Implications

specific issues. The aggregate portrait painted by GEO-5, however, presents a new and troubling image of the state and trends of our environment, with important implications for human well-being and the business community.

This section describes the business risks and opportunities that flow from GEO-5 trends and drivers across four dimensions – operations, markets, public policy, and reputation – for the following ten sectors:

- Building and construction
- Chemicals
- Electric power
- Extractives
- Finance
- Food and beverage
- Healthcare
- Information and communication technology
- Tourism
- Transportation

Note that some of the identified business opportunities may have negative impacts on the environment; the sole intent of this report is to identify them, not to assess their desirability.

While this report cannot predict how environmental trends and drivers may impact individual companies, it does provide critical data and insights that can help business leaders develop strategies to anticipate environmental changes and guide long-term success. There is, of course, overlap among the ten sectors. The interdependence among sectors means that impacts on one may very well trigger impacts on others.

Successful companies anticipate and adapt to changes taking place in the physical environment in which they operate. Since the environmental trends and drivers identified in GEO-5 are likely to impact all sectors in important yet diverse ways, recognizing and determining the strategic relevance of these trends and drivers – and embedding such analyses into core strategic planning – is a business imperative. GEO-5 makes clear the need to apply credible science to business decision-making – and to do so urgently.

Some of the specific environmental trends and underlying drivers identified in GEO-5 are already on the radar of many companies. Indeed, leading companies are taking meaningful actions to address biodiversity, water scarcity, climate change vulnerability, chemicals and wastes, and other

The interdependence among sectors means that impacts on one may very well trigger impacts on others.

3.1 Building and Construction

The building and construction sector – here considered to encompass construction, operation, and renovation of buildings (including residential) and civil infrastructure – faces some risks but also clear opportunities from environmental trends and underlying drivers. This sector has obvious ties to every other business sector, all of which own or use buildings, facilities, and infrastructure, as well as ties to the sectors upon which building and construction rely (e.g., electric power).

Operational Implications

Availability and cost of construction materials

Building materials such as concrete, steel, and aluminum are very energy-intensive to produce and to transport, so material costs for the building and construction sector are vulnerable to volatility in energy markets and increases in price (e.g., from climate-related constraints or costs on fossil fuels). Higher supply costs lead to increases in construction overheads and higher construction costs (which could erode profit margins and affect development decisions).[43]

Concerns about biodiversity and habitat loss, diminished carbon sinks, and declining water quality may lead to increased protection of forests and restrictions on logging, which in turn can result in declining production, constrained availability, and higher prices for timber. For example, in 1998 China imposed restrictions on logging due to concerns about droughts, flooding, and siltation of waterways. This led to a two-thirds decline in timber removals over the next five years – and a 20-30 percent increase in timber prices at the Beijing wood market.[44] Similarly, the expanding bark beetle epidemic causing massive tree die-offs in North America – likely due in part to climate-related increases in temperatures and droughts – may have serious impacts on timber supply and costs.[45]

Construction schedules and costs

Extreme weather events and changing climatic conditions will affect project completion timelines and costs. Water and wind damage, power outages, and work stoppages on high-heat days are likely to occur more frequently.[46] On the other hand, higher temperatures during winter months in colder climates may improve conditions for construction projects and reduce frost damage to buildings and roads.[47]

Construction practices

The construction industry is responsible for more than a third of global resource consumption (including 12 percent of all freshwater use) and generates about 40 percent of the total volume of solid waste, while manufacturing building materials uses about 10 percent of the global energy supply.[48] As concerns about climate change, waste, and resource scarcity increase, the sector is likely to come under increasing consumer and societal pressure to address its environmental impacts and to hasten the proliferation of sustainable, affordable construction practices.[49]

Location and design

Consideration of long- and short-term climate impacts (e.g., sea-level rise, high winds, precipitation changes, extreme weather events) will influence selection of sites, designs, construction techniques, and materials for buildings and infrastructure.[50]

Rising sea levels and storm surges may also drive the relocation of essential vulnerable equipment and infrastructure to higher ground (i.e., above flood levels). For example, in 2012, Hurricane Sandy caused extensive damage to transformers, circuit panels, and other basement-level electrical equipment in about 250 skyscrapers in Manhattan, knocking the power out for weeks and spurring building owners to begin relocating electrical infrastructure to higher, formerly rentable floors.[51]

Operations and maintenance

Floods, storms, fires, and extreme weather events will likely lead to more power outages and physical damages to buildings and infrastructure.[52]

Precipitation changes, flooding, warmer temperatures, and other impacts of climate change may lead to saturated ground conditions and thawing permafrost, affecting the integrity of foundations, pipelines, and other subsurface structures.[53]

Rising average temperatures will likely increase building cooling requirements and reduce heating requirements (though impacts will be location-dependent). In addition, longer and more intense heat waves may reduce the efficiency of passive techniques for cooling buildings (e.g., evaporative cooling or night ventilation).[54]

Climate-related increases in humidity levels may increase interior mold and condensation and decrease building thermal performance.[55]

Warmer temperatures and higher rainfall may lead to increased maintenance costs due to changes in corrosion of building facades.[56]

Market Implications

Global demand

Population growth, rapid urbanization, and economic development in emerging economies will translate to substantial demand for housing, new buildings, and new infrastructure.[57] By some estimates, US$40 trillion will need to be invested in urban infrastructure globally by 2030.[58]

Sustainable materials

As multiple environmental pressures grow, there may be increased customer demand for building materials and designs that incorporate renewable resources, recycled materials, and energy- and water-efficient technologies and processes.[59] For instance, the concrete and cement industries will likely continue to face pressure to reduce their electricity and water consumption, recycle concrete, and reduce their production of greenhouse gas emissions.[60]

New markets will likely be created for more sustainable products throughout the building and construction supply chains. In South Africa in 2009, paint manufacturer Dulux Trade accelerated the local development and production of its low VOC paints (which had previously been locally unavailable) to support a Nedbank building that was aiming to receive the first-ever 4-Star rating from the Green Building Council of South Africa, thus gaining first-mover advantage as a market for a new product emerged.[61]

Sustainable buildings

Increasing concerns about climate change, waste, and resource scarcity suggest that the market for greener buildings as a whole is likely to expand, driving into the mainstream a range of regionally-appropriate practices and technologies that promote on-site renewable energy and energy-, water-, and resource-efficiency.[62] LEED (Leadership in Energy and Environmental Design), for example, is already certifying 1.5 million square feet (more than 139,000 square meters) of building space every day in more than 130 countries,[63] and it is only one of several green building standards around the world. Building owners can see reduced operating costs, increased building values, greater return on investment, and higher occupancy from new and retrofitted green buildings.[64]

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As the shape of this market changes, there will be greater demand (and thus competitive advantages) for contractors and engineering consultants with sustainable design and construction skills and training.[65] Developers, designers, and construction companies that do not fully understand the detailed requirements for attaining and maintaining green-building certifications risk loss of market share and reputational damage.[66]

Disaster-resilient structures

There will likely be increasing demand to retrofit existing buildings and construct new buildings and infrastructure with enhanced resilience to climate impacts (e.g., buildings that can withstand hurricane-force winds, roads that are elevated above potential flood levels). Demand for coastal and flood defenses (e.g., seawalls) may also increase.[67]

Repair and reconstruction

Buildings and infrastructure damaged by climate impacts are generally repaired or rebuilt, which means there will likely be increasing regional surges in demand to clean up, fix, and replace structures that are lost or damaged due to floods, storms, wildfires, heat waves, and other climate-related extreme events.[68]

Limits on development opportunities

Concerns about water availability may limit potential development opportunities for builders in water-scarce regions, whether because market forces and physical water availability make development impractical or because regulators restrict or suspend developments due to insufficient projected water resource availability over the life of the project.[69]

Concerns about water quality impacts may limit potential development opportunities in particularly vulnerable freshwater ecosystems (e.g., wetlands).[70]

Policy Implications

Energy efficiency, renewable energy, and greenhouse gas emissions

Buildings are the largest contributor to global greenhouse gas emissions, with approximately one-third of global energy end use taking place within buildings.[71] As climate change impacts increase, regulatory measures in various regions of the world will likely continue to drive green building practices and technologies that reduce energy use and greenhouse gas emissions into the mainstream. Governments may utilize building energy efficiency codes, appliance standards, commissioning and audit programs, policies to encourage on-site renewable energy technologies, public procurement sustainability policies, and broader measures designed to reduce greenhouse gas emissions.[72] Where such policies are lacking, companies in the sector may still find it beneficial to act as if they are present, both in anticipation of the evolution of the regulatory environment and in recognition of the other economic benefits that come from green buildings.

Tax incentives, streamlined permit requirements, and other public policy measures to promote weatherization and other upgrades of existing energy-inefficient homes and buildings may help increase demand for, and enable implementation of, energy efficiency retrofit services and technologies.[73]

Beyond carbon dioxide, the building and construction sector is also responsible for significant levels of emissions of a variety of other greenhouse gases, including halocarbons, CFCs, HCFCs, and HFCs, due to their use in cooling, refrigeration, and insulation. Brick production may also be a locally significant source of black carbon in some regions. Rising concerns about climate change may lead to increased regulation of these sources of emissions as well.[74]

Water quality

Increasing concerns about water quality may lead to greater regulatory restrictions on stormwater run-off from construction sites, to ensure that soil and sediment runoff do not pollute waterways and aquifers. Companies may face considerable additional costs to implement erosion and sediment control and pollution prevention measures, discharge monitoring and sampling, and other compliance requirements.[75]

Waste

Given the large volumes of solid waste generated by the construction industry, increasing concerns about waste materials and the environmental impacts of landfills may lead to increasing regulations that restrict the quantity and types of waste allowed in landfills, particularly in developed countries. Taxes on the use of virgin materials (or subsidies for use of recycled materials) may also be applied, further spurring efforts to recycle and reuse waste from demolition and construction.[76]

Reputational Implications

Biodiversity and natural resources

A company's reputation with respect to protecting and restoring biodiversity and natural resources can affect its ability to have access to new sites. Likewise, restoring construction sites for the benefit of biodiversity can enhance companies' reputations among clients, funders, and others.[77]

Sustainable building certifications

Companies and their facilities may receive reputational benefits from achieving green building certifications. A 2011 survey of U.S. adults, for instance, found that 64% would prefer to patronize a business whose facility is certified as green, while 48% indicated that green certification of a facility improves their image of a company.[78]

3.2 Chemicals

The chemicals sector – here considered to encompass chemicals, mixtures of chemicals (formulations), and plastics – relies heavily on fossil fuels and water and faces constant consumer and regulatory concern about emissions to air and water, waste streams, and human health effects. At the same time, the sector can play a key role in advancing protection of the environment and human health. The chemicals sector also underlies and supports virtually every other sector, so as businesses feel the effects of and respond to environmental trends and underlying drivers, the chemicals sector will face both risks and opportunities.

Operational Implications

Fossil fuel costs

Oil and natural gas are the primary feedstocks for the chemical sector, though there is a new trend (led by China) towards coal-to-chemicals processes. Chemical production is also sometimes energy-intensive. Accordingly, the chemicals sector is exposed to fossil fuel price and supply fluctuations (e.g., from constraints or costs on fossil fuels imposed by climate-related policies).[79]

Rising energy prices may threaten the profitability of particularly energy-intensive chemical processes and may spur the sector to continue its efforts to improve energy efficiency.[80] Higher energy prices and climate change concerns may also drive chemical companies to diversify their feedstock base away from fossil fuels.[81]

Water availability

Chemical production is often water-intensive, using large amounts of water as a feedstock and for processes such as cooling, cleaning, dissolving, and diluting; at least as of 1995, the chemicals sector in both developed and developing countries used more water than any other manufacturing industry (42 percent of industry water use globally). Chemical production has been shifting over the last decade from developed countries to emerging economies such as China and India, which are expected to experience increasing water scarcity. As a result, the chemicals sector may experience markedly higher water costs or constrained operations due to increasing water scarcity.[82] In addition, the sector may face increasing pressure not only to re-design its processes to be more water-efficient but also to take greater care not to cause negative impacts to community water resources.[83]

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Business continuity

Extreme weather events linked to climate change can cause raw material shortfalls and supply chain and business continuity risks for the chemicals sector, negatively affecting operating margins.[84] More directly, extreme weather events can damage or destroy chemical plants and infrastructure; while this potential exists across all manufacturing sectors, the associated risk is higher at chemical plants due to the potential for hazardous chemical releases to air, land, and water.[85] For example, when typhoon Meihua hit Dalian in China in 2011 and broke the dyke protecting the Fujia Dahua petro-chemical plant, the city government ordered the plant to close and relocate away from the city to safeguard residents.[86]

Market Implications

Energy efficient/renewable energy products and technologies

Increasing efforts to address climate change will create larger markets for many specialized chemicals sector products and technologies, including those used in high-performance insulation, advanced lighting, renewable energy technologies and lightweight materials (e.g., for automobiles).[87]

Water treatment technologies

As water quality and scarcity challenges increase, in conjunction with population and urbanization, demand for chemical sector products that sterilize, purify, and desalinate water will rise correspondingly.[88]

Agricultural inputs

Concerns about climate impacts (e.g., droughts, increased range for pests), coupled with rising concerns about water scarcity, water quality, food security, and population growth, may create larger markets for life sciences chemical companies developing agricultural inputs designed to address such concerns (e.g., drought-resistant seeds, crop protection products).[89]

On the other hand, consumer and community concerns about environmental and health impacts from agricultural chemicals (e.g., fertilizer run-off, pesticide exposure) may lead to increased demand for sustainably grown and/or organic foods, which may reduce market demand for such chemicals.[90] (See section 3.6 below for more on impacts to the food and beverage sectors.)

Business customer expectations

Rising concerns about the environmental and health effects of chemicals and the amounts of hazardous chemicals in various waste streams are leading more companies to require higher standards and quality from their suppliers. These requirements, in turn, may affect chemical demand and management. For instance, companies such as Nike continue to pursue aggressive supply chain management programs with a focus on eliminating discharge of hazardous chemicals.[91] Walmart helped develop GreenWERCS, a software tool that helps retailers identify products with hazardous chemicals.[92]

Green chemistry and chemical leasing

Concerns about the proliferation of chemicals, inefficient use of chemicals, the environmental and health effects of chemicals, and the amounts of chemicals in various waste streams may increase market and regulatory pressure on the sector to alter its business models and products. This may include advancing "green chemistry" and "green plastics" efforts to create less hazardous and more sustainable (though often more expensive) chemicals and plastics, as Brazilian company Braskem has done.[93] It may also include providing chemical leasing services that decouple payment from chemical consumption volumes, thereby promoting better management of chemicals.[94]

Policy Implications

Product use restrictions and phase-outs

In response to concerns about the impacts of chemicals on human health, wildlife, water, and the atmosphere, regulatory measures may restrict usage of some chemical sector products, as well as sector emissions. Developed countries are already reducing certain types of chemical use. For example, total releases and transfers of the 152 pesticides that are common to the United States and Canada dropped by 18 percent, and the production of ozone-depleting substances almost stopped, while emissions of acid rain precursors dropped by 48 percent, ozone precursors by 38 percent, and non-methane volatile organic compounds by 26 percent.[95] Regulatory measures such as the Clean Air Act in the United States, as well as the Montreal Protocol, were key drivers of these reductions. In the EU, regulations such as the Water Framework Directive and, most notably, the regulation on Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH) are driving the phase-out of those chemicals that are judged to pose serious dangers to human health and the environment.[96]

Such regulations may also open up market opportunities to provide products that can substitute for the regulated products, as occurred with ozone depleting substances.[97]

Pollutant emissions and discharges

As chemical production continues to shift to emerging economies, those countries may face increasing pressure to enact chemical regulations that are more protective of environmental quality; for instance, a 2005 chemical spill into the Songhua River spurred revisions in China's Water Pollution Control Law.[98]

As concern grows over the cumulative effects of micro-pollutants in surface water on aquatic life and human health, discharge requirements for chemical plants may tighten.[99]

Greenhouse gas emissions

Given the energy-intensive nature of the chemical production process, climate change legislation and carbon taxes could impact the sector's costs and profitability, particularly given the shift in chemical production and consumption to emerging economies that tend to be less energy-efficient and more reliant on coal.[100]

Transparency

In many markets, in both developed and developing countries, the call for increased transparency is growing. The lack of publicly available data and rising concerns about the potential health and environmental risks posed by chemicals in products may increase regulatory pressure on chemical companies to generate, assess, and make publicly available baseline data on the health and environmental effects of chemicals in commerce (potentially including synergistic effects of chemical mixtures).[101]

Regulation of other industries

Regulations addressing environmental trends that directly affect other sectors may reduce or change markets for the chemicals sector. For instance, the European Union has enacted a two-year ban on widely-used pesticides containing neonicotinoids out of increasing concern about their potential contribution to declines in bee colonies, with resulting effects on pollination and crop production.[102] (See section 3.6 below for more on impacts to the food and beverage sector.)

Reputational Implications

Community conflicts

Increasing concern about water quality, air quality and other environmental conditions, particularly in the context of increasing population growth and urbanization, may lead to increased community sensitivity to the potential for chemical plants to impact the local environment (e.g., due to chemical releases). This heightened sensitivity can impact existing plants' operations and relationships with the community and can result in forced relocations or new plants being prevented from being built. Given the water-intensive nature of some chemical processing and manufacturing operations, the chemical sector faces similar reputational risks from conflicts with communities in water-scarce regions.[103]

Green chemistry

Greater use by chemical companies (and their business customers) of "green chemicals" or more sustainably produced conventional chemicals can enhance the reputation and brand value of those companies and their products, creating competitive advantages.[104]

3.3 Electric Power

The electric power sector – here considered to encompass generation, transmission, and distribution of electricity, but neither fuel source extraction (e.g., coal or uranium mining) nor any other utilities (e.g., district heating, water supply) – is highly exposed to environmental trends and their underlying drivers. The sector generally has intensive resource needs and impacts, as well as extensive infrastructure. It also has a major role in contributing and responding to climate change. In addition, the sector is closely intertwined with every other sector, and its product – electricity – is a fundamental necessity to most of modern society.

Operational Implications

Water availability

Electricity generation is water-intensive, accounting in 2010 for about 15 percent of global freshwater withdrawals and as much as 40 percent in developed countries (although much of this water is eventually returned to surface water bodies).[105] Water scarcity and a range of climate change impacts (e.g., droughts, changing precipitation levels and patterns) thus have operational implications for power generation. Hydroelectric generation is sensitive to changes in water volumes, timing, and geographical distribution, so climate-related changes in water resources and precipitation patterns may result in inadequate water for hydropower in some regions and more favorable water supply conditions in others.[106] Concentrated solar power systems also consume large amounts of water, often in water-scarce areas, and could thus face operational restrictions and higher costs as well.[107] Water scarcity may also limit generation from nuclear and fossil fuel power plants, which may require large amounts of water for cooling.[108] In India, for instance, low water levels at the Erai dam in 2010 and the Mun River in 2012 forced the Maharashtra State Power Generation Company (MahaGenco) to shut down thermal power stations at Chandrapur and Paras.[109] Thermal power plants may need to pursue alternatives such as air cooling or treating and using wastewater, which may lead to higher capital expenditures.[110]

Potential conflicts with competing users for limited water supplies in water-scarce areas may affect operations, particularly with respect to newly planned power plants.[111] New plants built without regard for potential regional water constraints run the risk of becoming stranded assets.[112] For example, plans for many dams in the Amazon, such as the Belo Monte project, do not account for the effects that deforestation and climate change may have on long-term regional water availability and energy production.[113]

Efforts to address climate change may increase the electric power sector's water requirements in some cases. Carbon capture and storage for coal-fired power plants, for example, can increase water consumption by 45 to 90 percent compared to conventional plants.[114]

Water temperature

Warmer temperatures in water bodies resulting from more severe and more frequent heat waves can limit their use as sources of cooling water and can restrict water discharges permitted from power plants (limiting power output in either case).[115] For instance, a serious heat wave in Europe in 2003 forced Électricité de France to limit or suspend operation of several nuclear plants due to elevated river temperatures. This led to a loss of €335 million after the company had to instead purchase higher-cost power on the open market.[116] Temperatures experienced during the 2003 heat wave are expected to be common during the European summer by mid-century.[117]

Power demand

Increasing average air temperatures and more frequent and severe heat waves associated with climate change will likely increase power demand (particularly peak power demand) for air conditioning in summer and reduce power demand in winter.[118] For instance, a record heat wave in the U.S. state of Texas in 2011 contributed to unprecedented electricity demand and price spikes, forcing Constellation Energy, the local utility, to purchase incremental power in the real-time market at peak prices and leading to an after-tax quarterly reduction of about US$0.16 per share.[119] By the end of the century, electricity demand in the U.S. state of California on almost all summer days is expected to be greater than the current 90th percentile per-capita peak load.[120]

The changes in demand, particularly due to extremely hot days, may result in decreased grid reliability and more power outages.[121] For example, the 2012 blackouts in Northern India, likely caused in part by higher demand due

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Electricity infrastructure

Extreme weather events, flooding, storm surges, and rising sea levels can cause extensive damage to generation, transmission, and distribution facilities and related infrastructure, particularly over the long lifetimes of the sector's fixed assets.[123] For instance, Hurricanes Katrina and Rita, which hit the U.S. Gulf Coast in 2005, forced one local utility, Entergy, to incur approximately $1.5 billion in restoration costs, repair more than 75,000 miles of transmission lines and distribution circuits, and relocate its headquarters from New Orleans.[124]

Increasing damage from extreme weather events will likely continue to add consumer and regulatory pressure for electric power companies to make their infrastructure and services more resilient.[125] Companies may need to harden, adapt, or relocate vulnerable infrastructure, expand redundancy in transmission capacity, and better prepare for supply interruptions (e.g., by investing in and maintaining more backup systems).[126]

Severe flooding and changes in precipitation and temperature may increase erosion and sediment loads, leading to increased silting of reservoirs, turbine blade damage, and reduced performance of hydropower dams.[127] In addition, rising sea levels may affect the assessment of long-term decommissioning liabilities for coastal nuclear power plants.[128]

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Concerns about biodiversity loss and food security could derail, or at least create pressure to reassess, planned hydropower dams, given the potentially significant ecological impacts of hydropower development.[129]

Increasing temperatures in cold regions may negatively impact the integrity of electric power infrastructure built on permafrost.[130]

Fuel supply reliability

The range of impacts from environmental trends and drivers on fossil fuel extraction (see section 3.4 below for more on impacts to the extractive sector) may disrupt fuel supplies for power plants reliant on coal, natural gas, or oil for electricity generation. At the same time, rapidly increasing demand for biomass (e.g., spurred by climate change policies and renewable energy incentives) may lead to fuel supply shortages and higher fuel prices for biomass power plants.[131]

Operational efficiency

Climate change may lead to changes in cloud cover (which is influenced by temperature, precipitation, and other factors), causing changes in the operational performance of solar powered electricity generation systems. Climate change may similarly alter wind speeds, affecting the operations of wind turbines.[132]

Warmer average air temperatures will likely lead to decreased gas turbine efficiency and greater losses in transmission and distribution systems.[133]

Market Implications

Electricity demand

Population growth, urbanization, and economic development in developing countries will lead to greater demand for electricity.[134] The IEA estimates that the power sector will need almost $17 trillion in investment by 2035 in order to meet worldwide electricity demand that may be over 70 percent higher than it was in 2009; most of this growth and required investment will be in developing countries.[135] Meeting this increased demand sustainably and efficiently, while remaining profitable, will be a systemic challenge for the sector, particularly as many urban areas have inadequate energy infrastructure capacity to meet such higher demand.[136]

Some solutions to other environmental pressures – such as desalinization of seawater in developing countries (in response to concerns about water scarcity) and electrification of vehicles in developed countries (in response to concerns about climate change and air pollution) – may further increase electricity demand.[137] In the United States, for instance, electricity demand attributable to electric vehicles is projected to rise more than 1700% by the end of the decade, from 146,000 megawatt hours (MWh) in 2010 to 2.6 million MWh in 2020.[138]

Fuel source mix

Concerns about climate change, air quality, water quality, and other environmental matters, coupled with regulatory mandates and incentives, are driving a general decarbonization of electricity. Coal's global share of total generation is expected to decrease from two-fifths to one-third by 2035, while renewables increase from 20% to 31%. Natural gas is expected to nearly overtake coal in the primary energy supply mix by 2035. Nuclear energy is expected to remain at about 12%, as interest in nuclear as a bulwark against climate change is offset by concerns about safety.[139] The 2010 Fukushima Daiichi nuclear power plant accident, for instance, drove Germany to announce a phase-out of nuclear energy by 2022.[140] If governments make robust commitments to limit global warming, the decarbonization of electricity will occur faster and go further than currently anticipated.

Increased demand for intermittent renewables and distributed generation in the electricity supply will likely increase demand for new electricity storage technologies and better and "smarter" power grids to manage the loads, which can create opportunities for non-traditional actors in the power sector.[141] Increased generation from intermittent renewables may also create opportunities for natural gas as a potential backup supply of power.[142]

In addition, concerns about climate change and energy security will spur greater efforts to rely on energy efficiency (i.e., "nega-watts") to meet increased electricity demand in developing and developed countries.[143]

Policy Implications

Greenhouse gas emissions, energy efficiency, and renewable energy

Legislation designed to reduce greenhouse gas emissions can have significant impacts on the electric power sector, as two-thirds of global electricity generation comes from fossil fuels. [144] The sector is already subject to carbon reduction regulations, carbon taxes, and fossil fuel subsidy reductions in some countries, and these will likely grow more widespread and restrictive over time, creating potentially significant costs and complex compliance challenges.[145] There will likely also be more regulations promoting energy efficiency and incentivizing customers to conserve energy, which could lead to changes in utility business models (which typically tie profits to electricity sales).[146] At the same time, there will be increasing opportunities for the sector to advance renewable energy technologies, particularly in places with mandates or incentives for renewable energy production.[147] The Canadian province of Ontario, for instance, will completely phase out coal-fired power plants by 2014 to address climate change and reduce air pollution, instead relying on new natural gas plants and a range of conservation and renewable energy initiatives, including feed-in tariffs that create business opportunities for renewable energy projects.[148]

Airborne pollutants

Electric power generation can produce significant amounts of sulfur dioxide, nitrogen oxides, mercury, and other airborne pollutants, depending on the fuel and technology used. As concerns about air quality grow in developed and especially in developing countries, regulations on air pollution may become more restrictive and costly for the sector.[149] For example, record levels of air pollution in China in early 2013 spurred the Ministry of Environmental Protection to impose stringent new emission limits on six sectors, including coal-fired power plants.[150]

Water use and quality

In areas increasingly concerned about water scarcity, the electric power sector may see more regulatory scrutiny, and in some cases rejection, of construction permits for new power plants that would require significant water inputs. New power plants may see greater restrictions on water use and efficiency, while existing plants may face increasing restrictions on the volume of allowed water withdrawals. For new plants, this may result in longer permitting and development periods and more difficult and expensive financing.[151]

Increasing concerns about water quality may result in stricter regulations of power plants' wastewater effluent discharges, particularly for coal-fired power plants, which can release arsenic, mercury, lead, and other pollutants in their wastewater streams. Similarly, the sector may see increased regulation of coal combustion waste to prevent coal ash spills and contamination of waterways.[152]

Biodiversity

Increasing concerns about impacts on biodiversity and habitat may lead to regulatory restrictions on siting of electric power development, including for renewables.[153]

Demand management

Energy price volatility and increasing incorporation of intermittent renewables into the electricity supply may spur regulators to expand time-of-use pricing and other programs designed to encourage time-shifting of energy use.[154]

Reputational Implications

Reliability

Electric power companies' service and reliability failures due to inadequate preparation for extreme weather events may cause adverse media, consumer, and investor reactions.[155]

Climate change

Electric power companies that remain reliant on coal or oil and incorporate inadequate levels of renewable energy and energy efficiency face reputational risks from being seen as major contributors to climate change.[156]

3.4 Extractives

Extractive companies – here considered to encompass oil and gas production and mining for all materials (e.g., metals, coal, gravel, clays) – must operate where the resources are found, thereby exposing them to highly localized environmental conditions. These industries also have strong links to other sectors, including providing materials for construction and fuels for the transportation and electric power sectors.

Operational Implications

Infrastructure damage and business continuity

Extreme weather events, increased wildfires, rising sea levels, and other impacts associated with climate change can damage extractive industries' infrastructure and equipment, disrupt operations and production schedules, disrupt transportation routes, and pose risks to the safety of employees.[157] For instance, in early 2011, Rio Tinto's operations in Australia experienced cyclones, heavy rains, widespread flooding, and a related train derailment, leading to a 5% decline in iron ore shipments from some operations, restricted production at a diamond mine, and a half-year shutdown of a processing plant at a uranium mine, all of which ultimately reduced the company's earnings by $245 million.[158] (See section 3.10 below for more on disruptions to transportation routes.)

Oil and gas companies often operate in extreme conditions (e.g., deepwater) and in locations prone to extreme climates and severe weather (e.g., the Arctic and the U.S. Gulf Coast). The operational damage to the industry from Hurricanes Katrina and Rita in 2005 – including the destruction of more than 100 production platforms, damage to more than 50 others, and damage to more than 450 sub-surface oil and gas pipelines in the Gulf of Mexico – illustrates the operational vulnerability of the industry to extreme weather events.[159]

Thawing permafrost can destabilize infrastructure like pipelines and airstrips in cold regions.[160] Furthermore, wandering "ice islands" calved from Greenland's glaciers, which may increase in number in a warming world, could potentially collide with drilling rigs or other infrastructure before eventually breaking up.[161]

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Physical access to resources

Warmer temperatures in the Arctic due to climate change can affect extractive industries' access to resources. Seasonal ice roads, on which extractive industries rely for winter operations, may be available for less time;[162] for instance, a warm winter in 2006 forced early closure of the ice roads that enabled fuel and supplies to reach Canadian diamond mines, leading to operational disruption, much higher operational costs (e.g., to use cargo airlifts instead), and in at least one instance the closing of a mine and bankruptcy of a company.[163] Thawing permafrost can also disrupt oil and gas operations in the Arctic that rely on a winter exploration season on the tundra.[164]

On the other hand, the warmer temperatures in the Arctic and decreasing seasonal Arctic Ocean sea ice cover will open previously inaccessible or uneconomical areas to exploration and extraction, as well as allow longer shipping seasons and new shipping routes in northern sea channels.[165]

Water availability

Mining and oil and gas operations are vulnerable to drought and changes in local water availability.[166] Mining typically relies on large amounts of water – for both open pit and underground extraction, as well as processing and refining – particularly for precious metals, diamonds, copper, and nickel. This water demand is likely to increase in coming years as many major commodities face declining ore grades. Reduced water availability in a region can constrain or stop production, increase competition with local communities and other industry sectors for water supplies, increase costs for pre-use and post-use water treatment, and spur regulators to either charge more for water or require mining operations to provide their own water supplies.[167]

Similarly, water scarcity and/or the need to create new freshwater supplies can increase the operational costs of and significantly constrain oil and gas exploration, oil refining, oil sands extraction and refining, natural gas extraction, and potential oil shale production.[168]

Community perceptions of extractive industries' impacts on water resources and the environment can directly bear on companies' ability to operate in some regions.[169] For example, in 2011, Newmont suspended construction activities at one of its gold and copper mines in Peru because of protests in the region about impacts on local water supplies.[170] Similar protests caused Newmont to cancel plans to expand another gold mine in 2004.[171] Natural gas extraction may face similar challenges related to concerns about water impacts.[172] Extractive companies that are proactive in addressing their environmental impacts and community concerns and that consistently maintain their social license to operate can therefore see a competitive advantage.[173]

Energy cost and reliability

The energy-intensive nature of mining operations may make operations that do not generate their own power vulnerable to electricity shortages (see section 3.3 above for more on impacts on the electric power sector) and to volatility in energy markets and prices, which can affect operational continuity and costs.[174] Inadequate energy supplies may seriously constrain expansion or development of new extractive projects in some areas.[175] For instance, extreme drought, population growth, and economic growth in South Africa, China, Chile, and other developing countries in 2008 led to electricity shortages and rationing that caused mine closures, significantly lower output, and higher metal prices.[176]

As temperatures rise due to climate change, energy needs for cooling underground mines and surface facilities may increase, while heating costs in colder climates may decrease.[177] Extractive companies may see greater need to increase investment in self-generation to ensure sufficient power for operational continuity.[178]

Decommissioning

Mining operations, including the mining of oil sands, face liability risks and higher decommissioning costs arising from assets such as tailings ponds and dams. Some of these assets may face an increased risk of failure – and thus may need to be re-evaluated and reinforced – as climate change alters precipitation patterns, exacerbates flooding, and raises air and water temperatures.[179] Illustrative of the risks from changing weather patterns was the 2010 collapse of a Hungarian bauxite mine's tailings dam due to heavy rain, killing ten people, injuring about 120, and leading the government to take over the company.[180]

Workforce

Dangerous heat stress caused by higher temperatures and humidity are likely to cut the world's outdoor labor capacity during summer months 10 percent from current levels and 20 percent from pre-industrial levels by mid-century.[181] In addition, changing patterns of disease – exacerbated by urbanization, globalization, poor water quality, and climate change – may affect the health of extractive businesses' employees.[182]

Market Implications

Overall demand

Population growth, urbanization, and economic development in developing countries will lead to greater demand for the energy, metals, and other materials needed to provide the goods and services associated with higher living standards, leading to larger markets for the mining and oil and gas industries.[183]

Demand for certain minerals and materials used in renewable energy, energy efficiency, air pollution control, and water purification technologies may increase as action accelerates to address climate change, air pollution, and water scarcity/quality.[184]

If consumers, investors, markets, and governments make serious efforts to limit global warming to 2°C above pre-industrial levels, large amounts (up to 80 percent) of the world's current proven reserves of oil, gas, and coal would have to remain unburned (or the carbon from their combustion would have to be captured). Over time, such stranded assets and reduced demand could seriously affect oil and gas and coal mining companies' markets and valuations, with leading oil and gas companies facing a potential 40 to 60 percent loss in market value.[185]

"Cleaner" energy

Companies and industries seen as major contributors to climate change, biodiversity loss, and other environmental problems can suffer not only reputational damage but also increased consumer, investor, lender, and insurer pressure to shift to "cleaner" and less damaging alternatives (or lose markets and investment to companies that do). Oil and gas companies, for instance, may face continued pressure to reduce carbon liabilities by increasing investment in cleaner-burning natural gas instead of oil and helping bring next-generation biofuels to commercial viability.[186] Similarly, companies that mine coal may limit expenditures on those assets given coal's impacts on climate change, as BHP Billiton recently announced it would do.[187]

New markets may also open for actors seen as being more environmentally responsible than their peers. For instance, the Responsible Jewellery Council created a certification scheme in 2009 for diamond and gold jewelry that includes specific waste, emissions, and biodiversity criteria for the entire supply chain, from mine to retail.[188]

Recovery and recycling

Many developing cities (and others) are exploring how to achieve zero waste, which includes recovering and recycling precious metals (e.g., gold, palladium) and rare earth elements from existing landfills.[189] This may reduce demand for virgin materials and create opportunities to "mine" landfills, particularly as e-waste is estimated to contain precious metal "deposits" 40 to 50 times richer than ores mined from the ground.[190]

Policy Implications

Water quality

Rising concern about water quality is leading to increased regulatory restrictions on extractive industries' operational practices. For instance, in recent years, mountain-top removal coal mining in the United States has faced heightened regulatory scrutiny due to concerns over impacts on stream water quality and aquatic and wildlife habitat.[191]

Similarly, concerns about impacts on groundwater from hydraulic fracturing ("fracking") for shale oil and natural gas have led some countries (e.g., France, South Africa) and U.S. states (e.g., New York) to ban, restrict, or temporarily suspend the practice.[192] The French ban on fracking in 2011 also revoked existing permits, thereby stranding large investments from companies such as Toreador, which saw its stock lose significant value in the following months.[193] Still, over time, financial risks from regulation might be larger in countries with weak water quality regulation, which are more likely to take costly retroactive action against companies when serious water quality problems occur.[194]

Water availability

Concerns about water scarcity may spur increased regulation that affects extractive industries' water rights and costs. For instance, in Chile, regulators asked a large copper mine to reduce its rate of water extraction by more than half.[195] In South Africa, platinum mines in the Olifants River system are expected to face water charges ten times their current value by 2020 due to water scarcity in the region.[196]

Greenhouse gas emissions

Mining sector operations are responsible for about two percent of global greenhouse gas emissions, while combustion of oil, gas, and coal mining companies' products in vehicles, power plants, and elsewhere is the key driver of anthropogenic climate change. These sectors are already subject to carbon reduction and gas flaring regulations, carbon taxes and pricing, and fossil fuel subsidy reductions in some countries, and these will likely grow more widespread and restrictive over time, posing potentially significant costs, restricting demand for products, and creating complex compliance, monitoring, reporting, and verification challenges.[197] On the other hand, climate-related policies may create opportunities for natural gas as the least carbon-intensive fossil fuel and as a potential backup for electricity generation from intermittent renewable sources (see section 3.3 above for more on impacts on the electric power sector).[198]

Biodiversity

Limitations on the areas available for future exploration by extractive industries may be imposed by legislation designed to expand protected areas for marine and terrestrial biodiversity, increase legal protection of existing protected areas, or protect forested areas that serve as carbon sinks. Regulatory attempts to manage the competing demands for land caused by urbanization, food security, biodiversity protection, and other sources may further restrict access to resources.[199]

Mercury

Mercury is used in developing countries to amalgamate gold in artisanal mining, causing health problems, neurological impairment, and pollution. It is also more broadly involved in smelting. A global legally binding treaty to control and reduce mercury use across a range of products, processes, and industries was adopted in January 2013, which may lead to restraints on the use of mercury in the mining and minerals sector.[200]

Reputational Implications

Water

Community opposition to extractive projects due to concerns over water impacts, as occurred with Newmont in Peru (see above under Operational Implications), can affect not only the operations in question but the company's broader reputation and value. During the 2004 Peru protests, Newmont's stock price dropped seven percent in two weeks. Perceived water pollution problems in Indonesia at the same time also damaged Newmont's reputation and increased the challenges that future projects in that country might face. Furthermore, these conflicts in Peru and Indonesia affected local perceptions of the company's mines around the world.[201]

Biodiversity

Campaigns by advocacy groups and others addressing extractive projects' potential impacts on biodiversity have created reputational (and operational) challenges for the industry. For instance, the proposed Pebble Mine at the headwaters of Bristol Bay in Alaska, which is being proposed by Anglo American and Northern Dynasty, has faced stiff organized opposition from environmental groups and some jewelry companies due to concerns over pollution and impacts on salmon.[202] As pressure increases on biodiversity and habitats, resistance to extractive operations with potentially detrimental impacts on vulnerable ecosystems will likely also increase.[203]

Climate change

The oil and coal industries are closely tied in the public eye to climate change and therefore face reputational challenges as climate change and its consequences become more pronounced. In addition, these companies often operate in politically, socially, and economically challenging regions of the world that are vulnerable to climate change impacts. The extent to which the industries support (or at least do not undermine) local communities' resilience to climate impacts may affect their reputations and social license to operate.[204] At the same time, companies with a focus on natural gas may see reputational gains from the role natural gas can play as a lower-carbon fossil fuel and as potential backup for intermittent renewables, assuming companies are viewed as minimizing methane leaks and extracting the gas in a responsible manner.[205]

3.5 Finance

The finance sector – here considered to encompass lending, investment, and insurance – underlies activities in all other sectors. Uniquely among sectors, the finance sector is exposed to the impacts of environmental trends and their underlying drivers mostly because of the impacts on other sectors

Operational Implications

Insuring

Insurance companies rely on past events to accurately underwrite and price future risks. Climate change may force insurers to revisit that approach, as they confront dramatically different weather patterns and extreme weather events. This may hinder the industry's ability to price physical perils, create new types of liability exposures, threaten insurance affordability and availability, and have potentially serious ramifications for insurer profitability. Property and casualty insurers will likely see increasing claims due to severe weather. Health insurers may see increasing claims due to expanded disease ranges. Reinsurers may be exposed to all losses, including those due to catastrophic events.[206]

Population growth, urbanization, development (especially in coastal areas), river channelization, floodplain loss, and changing land use add to the increasing impacts of extreme events such as floods and droughts.[207] For instance, the 2010-2011 floods in Australia resulted in more than $350 million in claims to Munich Re, which were partly responsible for the company's quarterly profit decline of 38%.[208] Insurers with less capacity or willingness to identify, plan for, and manage a wide range of climate-related risks in underwriting and capital decisions may experience severe capital losses and markedly reduced profitability.[209] Insurers may also need to increase efforts to transfer risks from insurance markets to capital markets via catastrophe risk securitizations.[210]

Investing and lending

The impacts of various environmental trends and drivers on a range of sectors may increase pressure to integrate environmental issues into lending and investment decision-making.[211] Financial institutions may need to enhance coordination with the scientific community to ensure access to environmental information useful to the finance sector.[212]

As part of their due diligence, risk management, and portfolio monitoring, lenders and investors will need to understand how environmental trends and drivers affect consumer behavior, product demand, the legal liability of companies with severe negative impacts on ecosystems, and the competitiveness of sectors and companies in various geographies.[213] Clients of the International Finance Corporation now have to apply the IFC's Performance Standards to manage environmental and social risks and impacts, including Performance Standard 6 on Biodiversity Conservation and Sustainable Management of Living Natural Resources.[214] Further revisions by the IFC to strengthen its standards may drive similar changes by the dozens of financial institutions that have adopted the Equator Principles (pledging to identify, assess, and manage environmental and social risks in project finance transactions). The Principles are likely to be updated soon to include project-related corporate loans and bridge loans.[215]

Investors may see decreased investment returns from companies that face financial difficulties, disrupted business operations, and damaged reputations from climate change, water scarcity, biodiversity loss, or corporate impacts on ecosystems. Companies facing such financial difficulties, disrupted business operations, and damaged reputations may also pose greater default risks.[216] Institutional investors (such as insurers and pension funds) that have a long-term horizon and a large, diversified portfolio (i.e., universal owners) may have their returns affected by the systemic impact of environmental trends and drivers on the overall economy.[217] Natural resource and environmental risks may also have financially material impacts on sovereign bond markets.[218]

Business continuity

Increasing physical impacts from climate change, water scarcity, and other environmental trends may have direct impacts on financial sector operations, including damage to or disrupted operations at data centers and office buildings (see section 3.1 above for more on impacts to the building and construction sector), temporary closure of stock and bond markets, and more frequent power outages resulting in data security threats, loss of access to information, and disrupted client services.[219]

Market Implications

Investments in environmental solutions

Attempts by governments and others to address the range of impacts from environmental trends and drivers will likely require private sector investment, as the necessary capital requirements could exceed US$1 trillion per year for the next few decades. It is estimated that more than 80 percent of the capital needed to address climate change may come from the private sector. Given that many low-carbon technologies are capital cost intensive, the additional financing requirements and need for financial innovations may be significant. This may mean increased creation of attractive "green economy" investment opportunities for

the finance sector, including opportunities in clean energy and climate-resilient infrastructure, assuming other hurdles to private investment can be addressed (e.g., availability of policy risk insurance).[220]

Enhanced awareness of environmental trends and drivers may lead to new or expanded markets and investment products incorporating environmental criteria and/or targeting solutions for issues such as climate change, water, and agriculture.[221] For instance, increasing concerns about climate change and energy in the buildings sector may make green property an increasingly attractive asset class.[222] (See section 3.1 above for more on the impacts on the building and construction sector.) In addition, investors may see greater opportunities in solutions such as water supply infrastructure and wastewater treatment.[223]

Opportunities may also emerge from environmental challenges; for example, commodity traders may find abundant opportunities related to water supply uncertainty in agricultural commodity markets.[224]

Stranded assets, reduced demand, and systemic risks

Serious efforts to limit global warming to 2°C above pre-industrial levels may lead to reduced fossil fuel demand and large amounts of oil, gas, and coal reserves becoming stranded assets. (See section 3.4 above for more on the impacts on the extractives sector.) Over a long-term time horizon, the risk of unburnable carbon may leave investors in fossil fuel companies significantly exposed and may pose systemic risks to financial markets.[225]

Insurance

Population growth, urbanization, and economic development in developing countries (and, to a lesser extent, developed countries) may lead to greater demand for property insurance coverage. With rising risks from climate change and other environmental trends, the insurance industry is likely to see growth in premiums collected, claims paid, and potentially income (where insurers can overcome consumer and regulatory pressures to keep insurance rates artificially low). Where such pressures cannot be overcome, market dislocations may occur as the industry declines to provide coverage (which may create reputational risks).[226]

Biodiversity loss, ecosystem degradation, water management, and climate change may present insurance sector opportunities across agroforestry, casualty, health, life, property, and marine, aviation, and transport.

Insurance can be one of the key tools utilized by other sectors, governments, and individuals as part of efforts to adapt to climate change and other environmental trends, and the industry is exploring the commercial viability of new products and services that address global sustainability issues.[227] Biodiversity loss, ecosystem degradation, water management, and climate change may present insurance sector opportunities across agroforestry, casualty, health, life, property, and marine, aviation, and transport.[228] For instance, Swiss Re (along with Oxfam America and the World Food Programme) is leading an initiative to help poor rural communities protect their crops from climate change impacts through weather-indexed insurance paid for with work on local climate adaptation projects; the goal is to create a commercially viable business model.[229]

Increasing climate change concerns may create expanded markets for insurance products that encourage the spread of more energy-efficient homes and buildings and renewable energy technologies.[230] Given the range of ways that water scarcity, climate change, and other environmental factors can disrupt businesses' operations, insurance companies may also see a greatly expanded market for business-interruption insurance policies.[231]

Transparency and disclosure

As concerns about the impacts of environmental trends and drivers increase, investors may increase pressure on companies to improve disclosure of their impacts on and from environmental trends such as water scarcity, climate change, and biodiversity loss, as well as of the risk assessment and management processes they have in place and the companies' views on the materiality of the risks. Finance sector companies themselves may face increasing pressure from shareholders to issue sustainability reports and to report on their assessments of (and programs to address) the greenhouse gas emissions and other environmental impacts related to their lending, investing, and financing portfolios.[232]

Policy Implications

Market-based policy mechanisms

Regulations utilizing market mechanisms to address climate change and potentially the decline of biodiversity and ecosystem services may create new or expanded trading and investment opportunities for the finance sector, such as biodiversity offsets, water credits, and forest carbon credits.[233]

Required consideration of environmental criteria

Responding to the increasing impacts of environmental trends and drivers, financial regulators in both developed and developing countries may require financial institutions to establish procedures that factor environmental criteria into lending decisions and promote green financing, as China, Brazil, and Bangladesh have already done.[234]

Improved disclosure of environmental risks

Growing awareness of the impacts of environmental trends and drivers is spurring governments and stock exchanges in both developed and developing countries to require or encourage improved corporate disclosure of environmental impacts and risks, providing financial institutions with greater levels of information to incorporate into their decision-making.[235]

Changing regulatory environments

Developing countries experiencing the impacts of environmental trends and drivers and increasing their economic development (and institutional capacity) may strengthen currently weak regulations in order to address those trends and drivers, leading to very different regulatory regimes for companies operating in those countries. This means that equity-related investments with a short-term horizon and debt-related investments with a longer-term horizon may see different risk profiles in those markets.[236]

Reputational Implications

Environmental impacts of clients and projects

As concerns about the impacts of environmental trends and drivers increase, companies that inflict damage on ecosystems or that contribute significantly to climate change may face rising reputational risks. Companies in the finance sector that invest in or lend to those companies may face the same risks. Many commercial banks have already started to experience this with respect to the deforestation associated with palm oil expansion and have started to strengthen their risk assessment policies and policy statements on palm oil loans.[237]

Financial sector companies with reputations for having thorough understanding, knowledge, and preparedness with respect to a range of sustainability issues may be better able to attract and retain clients and employees.[238]

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3.6 Food and Beverage

The food and beverage sector – here considered to encompass crop agriculture, food and beverage processing, and food and beverage retail / marketing – is perhaps the most exposed of all sectors to changes in the environment. With sizable water requirements and heavy reliance on ecosystem services, changes to climate, weather, and water patterns pose significant risks and opportunities to the sector. With close ties to several other sectors, including extractives and transport, the food and beverage sector is exposed in many ways to environmental trends and underlying drivers.

Operational Implications

Availability, quality, and price of crops and livestock

Climate change impacts – including changes in temperature averages and extremes, precipitation patterns and volumes, ranges of diseases and pests, and incidence of extreme weather events, droughts, and floods – will affect the growing conditions for crops, as well as livestock, aquaculture, and marine health and performance. The net effect of projected warming trends is mostly negative (particularly at lower latitudes), though it may be positive for some crops in some regions at low levels of warming (e.g., due to longer growing seasons). Farmers are finding that climate change is producing unusual conditions they are ill-prepared to manage.[239]

In addition, rising nitrogen oxide (NOx) emissions and thus ground-level ozone levels in Asia and other developing regions will have impacts on vegetation and crops (both positive, as nitrogen deposition can increase crop yields, and negative, as increased ground level ozone can decrease crop yields) and increase eutrophication and acidification in both terrestrial and aquatic ecosystems.[240]

Furthermore, habitat loss, invasive species, urbanization, pesticide usage, and other factors are leading to loss of native bees and other pollinators, which may affect local crop yield quantity and quality and may require increased use of artificial pollination techniques.[241]

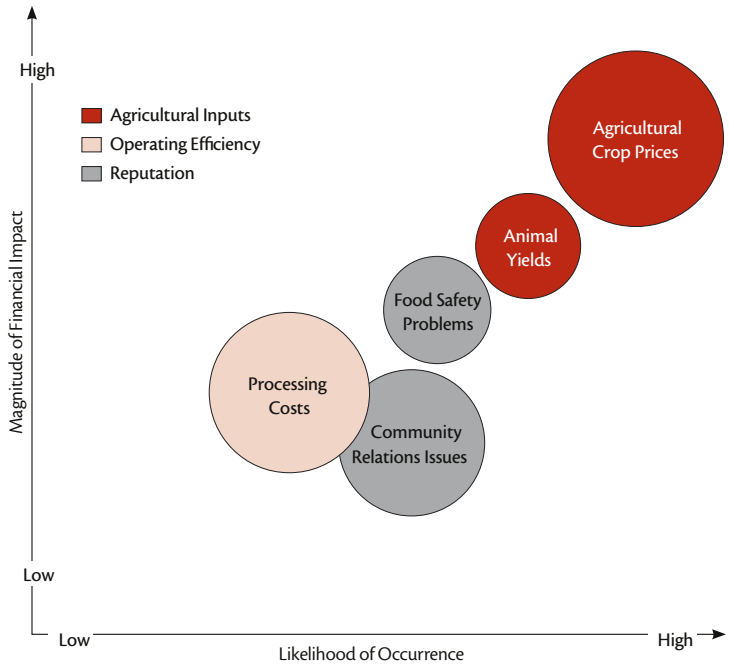
Food and beverage companies will thus face unpredictable availability, quality, and price of agricultural products, cutting into profits and potentially forcing them to raise prices to offset higher levels of commodity spending.[242] For instance, it is estimated that a one percent rise in sugarcane costs due to the effects of climate change, water scarcity, and floods could reduce the profits of Indian sugar company Balrampur Chini Mills by 3 to 10 percent.[243] Similarly, the severe U.S. droughts in 2012 led to record-high prices for grain, thereby eroding profits for livestock producers and restaurant owners and increasing the potential for beef, pork, and chicken prices to rise significantly.[244]

Companies in the food and beverage sector are already starting to identify alternative sources or develop more climate-resilient varieties of key supplies. While this may increase short-term costs, it may also improve long-term resilience and business performance.[245] The challenges may be particularly acute for alcoholic beverage companies, given the very regional nature of grape and hop cultivation and the susceptibility of grapes to even small changes in climate.[246]

Growing zones

Warming temperatures in colder climates may create new opportunities for food and beverage companies to expand (or shift) their growing zones and, given declining seasonal Arctic Ocean ice cover, to ship products to new markets.[247] For instance, some food and agribusiness companies are starting to shift investment from facilities (e.g., silos, rail cars) in places such as the U.S. state of Kansas to places such as Canada and the northern United States in anticipation of shifting grain production in those regions.[248]

Sector risk magnitude of impacts of climate change and water scarcity on the F&B sector in South and Southeast Asia



Source: World Resources Institute and HSBC Climate Change (2010). *Weeding Risk. Financial Impacts of Climate Change and Water Scarcity on Asia's Food and Beverage.*

Infrastructure and distribution networks

Rising sea levels, warmer temperatures, and extreme weather events associated with climate change can affect food and beverage companies' infrastructure, operations, and distribution networks. Impacts may include damage to facilities, greater demand on cooling systems to prevent food spoilage or impacts to animal health, and stranded products when transportation networks (e.g., ports) are compromised.[249]

Energy cost

Droughts and other climate impacts can also lead to higher electricity prices, driving up costs not only for food and beverage processing plants' direct power usage but also for production of key sector supplies (e.g., aluminum for cans) (see section 3.3 above for more on impacts to the electric power sector).[250]

Agriculture is reliant on fossil fuels, both for energy (to pump irrigation water, process and transport food and beverages, and fuel fishing fleets and farm equipment) and for feedstocks (for producing pesticides and fertilizers). This makes the sector vulnerable to volatility in energy markets and increases in price (e.g., from constraints or costs on fossil fuels imposed by climate-related policies).[251]

Workforce

Dangerous heat stress caused by higher temperatures and humidity are likely to cut the world's outdoor labor capacity during summer months 10 percent from current levels and 20 percent from pre-industrial levels by mid-century.[252]

Water availability and quality

For the food and beverage sector, water consumption in manufacturing and processing pales in comparison to water usage in producing raw materials.[253] Agriculture is the largest global water user by far – accounting for 70 percent of global freshwater use – and agricultural water withdrawals are projected to continue to rise.[254]

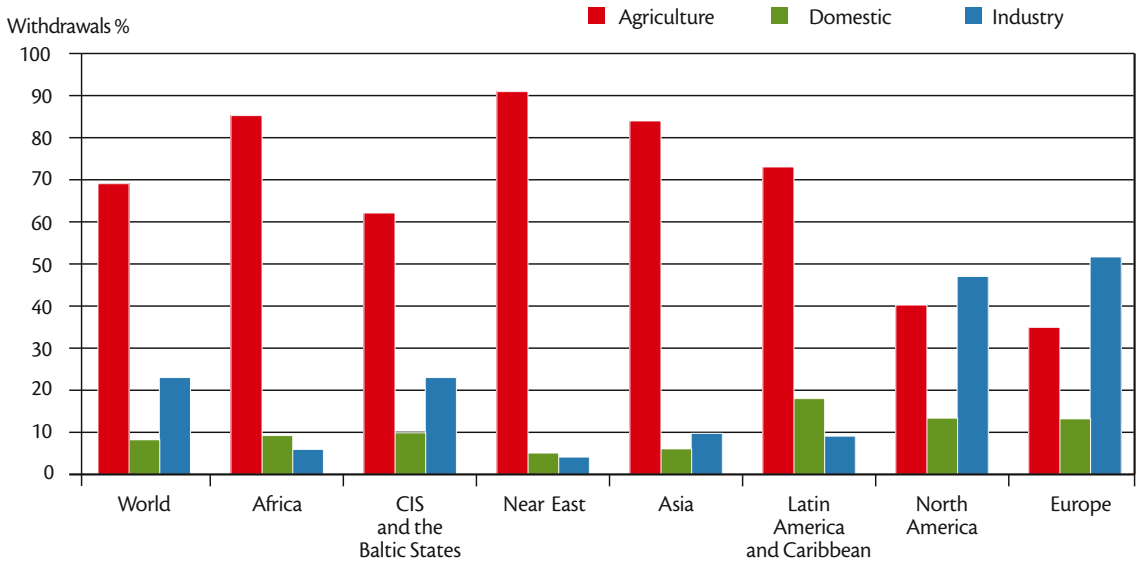
Water scarcity can not only affect crop yields and production (and thus agricultural input prices), but also lead to conflicts between companies, local communities, and other water users, posing risks to corporate reputations and potentially disrupting operations.[255] This dynamic can be particularly fraught in places where water use is highly inequitable, such as in India, where 10 percent of large farms consume 90 percent of groundwater.[256]

Water scarcity and water quality concerns pose particular challenges for beverage companies, which rely on freshwater as their primary ingredient. Inadequate supplies of high-quality water at bottling plants in various regions of the world may disrupt operations, compromise the quality and safety of products, and increase costs for treating and accessing water. In addition, community concerns about large water withdrawals can block or delay new or expanded beverage and bottling plants (or force closure of existing ones) and harm corporate reputations. Coca-Cola and Nestlé are among the beverage companies that have already faced such community opposition.[257]

Competition for arable land

Competing demands for food, feed, fuel, fiber, and raw materials will continue to intensify pressures on land, driven by population growth, globalization, urbanization, changing diets, climate change, biofuels production, and other factors.[258] This growing pressure for other land uses, coupled with land degradation, could reduce potential land available for agriculture.[259]

Water withdrawals by region and by sector



Source: FAO 2002. *Crops and drops:* making the best use of water for agriculture

Concerns about declining biodiversity, habitat loss, and protection of carbon sinks may lead to increased protections for forests and other ecologically valuable lands, further constraining the amount of land into which food and beverage companies can expand their agricultural operations or supply chains. This may spur companies in the sector to focus on reducing food loss and waste (currently accounting for about one-third of all food produced for human consumption) and increasing yields on current lands (e.g., via sustainable intensification techniques), particularly in developing countries.[260]

Given that organic cultivation may result in lower yields, the expanding market for organically-grown food (see Market Implications below) may further increase the competition for arable land.[261]

Availability of seafood stocks

Increased ocean acidity affects marine animals, particularly those with carbonate shells and skeletons, including species such as crabs and mollusks that are consumed by humans, as well as some plankton species important for the marine food chain. Ocean acidification and higher water temperatures are thought to be major factors in the destruction of coral reef ecosystems around the world, which provide spawning and nursery grounds for some commercially important fish species. Rising percentages of marine fish stocks are also overexploited, depleted, or recovering from depletion, and studies suggest that climate change may shift more than 1,000 marine species polewards about 40 km per decade, leading to local extinctions and disruption of community composition.[262] In addition, turbidity from upstream erosion and chemicals in industrial and agricultural run-off can lead to disease and mortality in fish. Combined, the impacts on seafood supplies and businesses could be significant, affecting availability, costs, and profit margins.[264]

Market Implications

Overall demand

Population growth, urbanization, and increased economic development in developing countries will lead to greater demand for food, including increasing demand for meat, dairy, and processed foods from growing middle classes in developing countries.[265] Meeting the demand for meat production may be constrained by increased consumer and regulatory pressure to address the water, health, land, and climate impacts of such production.[266]

Sustainable food production

Concerns about chemicals, pollution, and ocean health may create increasing demand from consumers and retailers for sustainably grown or caught foods, representing a potential area for increased revenue streams and markets.[267] In developed countries, consumer interest in sustainably grown foods may continue to rise; for example, the major markets for organic food and beverages expanded on average by 10 to 20 percent per year between 2000 and 2007.[268]

Beverage products

Warmer average temperatures, heat waves, and droughts associated with climate change, coupled with economic development and increased water scarcity and water quality concerns, may increase demand for beverage companies' products, particularly in developing countries.[269] On the other hand, increasing concerns about water availability and plastic waste may reduce consumer demand for bottled water in some markets.[270]

Chemical and fertilizer use

Increasing concerns about the impacts of chemicals and fertilizers on the environment, wildlife, and human health may lead to greater consumer and regulatory pressure to eliminate, minimize, or better manage the agricultural chemicals on which conventional agriculture depends. Such pressure is likely both in developing countries, where 99 percent of current global deaths from pesticide exposure occur, and in developed countries.[271]

Policy Implications

Greenhouse gas emissions

Policy actions designed to reduce greenhouse gas emissions may impact food and agricultural producers, who generate a substantial amount of greenhouse gas emissions, most of which are attributable to livestock and land use change. Policy initiatives to stop deforestation are already under development (e.g., REDD+), and regulations, certification schemes, and other mechanisms designed to limit further expansion of palm oil into forests are growing (e.g., the Roundtable on Sustainable Palm Oil). Some existing and planned cap-and-trade schemes already encompass fertilizer companies and meat and dairy producers, and more efforts to target emissions from agricultural production are likely.[272] Policy initiatives that encourage emission reductions through expansion of biofuels may intensify competition for the food crops used in their production or for irrigated cropland.[273]

Policy actions designed to reduce greenhouse gas emissions may impact food and agricultural producers, who generate a substantial amount of greenhouse gas emissions, most of which are attributable to livestock and land use change.

Fishing fleets, which contribute 1.2 percent of global greenhouse gas emissions, may face reduced subsidies for trawlers, which generate high emissions per ton of fish landed.[274]

Water

Expanding concerns about water scarcity, and increasing competition over limited water supplies by industrial, energy, and domestic users, may lead to a range of government policy actions on water use by agriculture. Actions may include reduced subsidies, incentives for installing modern irrigation systems, regulatory disincentives for planting water-thirsty crops, caps on water withdrawals, and reallocation of water towards other uses.[275] The Murray-Darling Basin in Australia, for instance, operates under a Basin Plan that defines the arrangements for sharing the water available for consumptive use among competing users, including agriculture.[276]

Water quality concerns may lead to stricter regulations on wastewater discharges (e.g., nutrient run-off) from food and beverage sector companies.[277]

Meat production

Increasing concerns about waste, air pollution, water pollution, and climate change may result in more numerous and more stringent regulations on meat production and processing, including restrictions on industrial pollution from slaughterhouses and manure management in concentrated animal feeding operations.[278]

Fisheries

Declining biodiversity, increasing ocean acidification, and increasing pollution may spur increased regulatory restrictions on fisheries.[279]

Reputational Implications

Water

Food and beverage companies that take steps to improve their water efficiency (both in agricultural supply chains and in processing plants and other facilities) and to engage with local farmers, communities, and NGOs to address local and watershed-level water challenges may see reputational benefits, in addition to operational savings and competitive advantages.[280]

Biodiversity

Food companies that fail to address their impacts on forest loss, biodiversity loss, and other declining environmental indicators may face high-profile NGO campaigns that cause reputational damage.[281]

Genetic modification

As water scarcity, droughts, and climate change increase the need for more resilient food varieties, use of species that have been genetically modified to adapt to those conditions may also increase. This in turn may have reputational implications for food companies, given disputes over the environmental and health risks and benefits posed by genetically modified organisms (GMOs).[282]

Food safety

Increasing temperatures and declining availability of high-quality water raises the risks of contamination of food and beverage companies' products. Incidents of contamination may harm corporate reputations, depress sales, and lead to lost revenues.[283]

3.7 Healthcare

The healthcare sector – here considered to encompass pharmaceuticals, medical diagnostics/devices, hospitals, surgical centers, and other healthcare facilities – faces unique impacts from environmental trends and drivers, many of which relate, not surprisingly, to the effects of those trends and drivers on human health. The sector also faces some more direct risks and opportunities, some of which tie to other sectors (e.g., buildings, electric power).

Operational Implications

Operational continuity of healthcare facilities

Hospitals and other healthcare facilities may face increasing threats from sea level rise, droughts, heat waves, and extreme weather events associated with climate change, including damage from flooding and storm surges, which can cause electric service and backup power generators to fail. Damaged healthcare facilities without power will be unable to keep medical devices (e.g., ventilators) running and unable to use computers to track patients and dispense medications, thereby necessitating evacuation of patients. Existing healthcare facilities may need to relocate critical components like backup generators to higher floors, while new ones may be sited and built to minimize risks from local hazards.[284] (See section 3.1 above for more on impacts to the building and construction sector.)

Sustainable hospital operations

Given the sector's mandate to promote human health, hospitals may face increasing pressure to improve their sustainability, including keeping medicines out of the waste stream, reducing energy use, and reducing use of toxic substances in cleaning and other products. Hospitals can see long-term operational savings from adopting broader green building initiatives, including savings from improved energy, water, and waste efficiencies.[285]

Energy and water costs

Hospitals are extremely energy-intensive; in fact, they use almost twice as much energy per square meter as traditional office space. In Brazil, for example, it is estimated that hospitals account for more than 10 percent of the country's commercial energy use. This intensive energy use, to the extent it relies on fossil fuels, means that hospitals' operating costs are vulnerable to volatility in energy markets and increases in price (e.g., from constraints or costs on fossil fuels imposed by climate-related policies).[286]

Pharmaceutical companies use large amounts of water and energy in developing and manufacturing drugs. While water and energy costs are usually a small percentage of total production costs, they can still be significant. For instance, in 2002, the total cost of purchased fuels and electricity in the U.S. pharmaceutical industry was nearly $1 billion. As climate and water concerns rise, the industry may see increasing operational costs and/or restrictions.[287]

Drug discovery, development, and production

Roughly a quarter of the pharmaceutical market is derived from active ingredients from nature, and natural compounds are still significant leads or sources for new medicines (although fewer companies still undertake active bio-prospecting). Biodiversity loss will limit discovery of such compounds. One estimate suggests that current extinction rates mean the Earth is losing one major drug every two years.[288] Drug manufacturing also relies on inert raw materials such as sugar, fish oils, soya, palm oil, titanium dioxide, and talc. (See sections 3.1 and 3.6 above for more on impacts to the extractive and food and beverage sectors.) Active and inert ingredients vulnerable to ecosystem services degradation and other environmental trends may disrupt the pharmaceutical industry's supply chains and cause a greater shift towards creation of more costly synthetic alternatives.[289]

Market Implications

Overall demand

Population growth, urbanization, and economic development in developing countries will lead to rising demand for healthcare services – demand that may be challenging for the sector to meet given rising pollution levels, urban slums with poor sanitation and freshwater access, and the impacts of climate change.[290]

Biodiversity loss will limit discovery of new medicines. One estimate suggests that current extinction rates mean the Earth is losing one major drug every two years.

Increased and altered disease burdens and ranges, as described below, may create greater demand for provision of healthcare services, drugs, and vaccination, particularly in developing countries, although increased mortality (including from extreme temperatures and extreme weather events) and some marginal potential health improvements due to climate change (e.g., smaller malarial zones in parts of Africa) may somewhat reduce such demand growth.[291]

Respiratory and cardiovascular illnesses

High levels of particulate matter concentrations in the indoor and outdoor air of many cities in Latin America, Asia, and Africa – often related to the energy, transport, and industrial sectors, as well as burning of waste and crop residues – may lead to increased levels of respiratory and cardiovascular illnesses. Both indoor and outdoor air pollution also cause more than 3 million premature deaths worldwide each year.[292]

Rising ozone concentrations in rapidly industrializing regions are second only to particulate matter in damaging human health, leading to lung damage and causing an estimated 700,000 respiratory deaths per year (more than 75 percent of which are in Asia).[293]

Sun exposure diseases

The drastic reduction in consumption of ozone-depleting substances (ODS) may help avoid higher incidences of skin cancer, cataracts, and immune system suppression in the future. However, stratospheric concentrations of ODS remain high due to their long atmospheric lifetimes, which means these health impacts (and demand for healthcare services to address them) may also remain high for some time.[294]

Lead and other toxic pollution

The largely successful phase-out of lead from fuel has resulted in very significant reductions in levels of lead in human blood, greatly minimizing incidence of lead poisoning and its adverse and often irreversible health effects in humans, especially children.[295] On the other hand, it is estimated that close to 125 million people are at risk from hazardous pollution, including lead, across 49 low- to middle-income countries – a global burden of disease on par with malaria – with the greatest impacts coming from lead-acid battery recycling and lead smelting.[296]

Increased exposure to growing numbers of toxic chemicals may lead to greater incidence of various health outcomes, including damage to organs such as the brain, lungs, liver, or kidneys; damage to the immune, respiratory, cardiovascular, nervous, reproductive, or endocrine systems; and birth defects and chronic diseases, such as cancer, asthma, or diabetes. This is particularly the case in low- and middle-income countries, where chemical intensity is rising and where healthcare costs related to chemical exposures will become increasingly significant.[297]

Waterborne and vector-borne diseases

Contaminated water, particularly in Africa and South Asia, causes a range of waterborne diseases, including diarrhea, which is one of the largest contributors to the global disease burden. Warming temperatures, changes in precipitation patterns and levels, flooding, and other climate impacts can affect the distribution and incidence of waterborne diseases, as well as vector-borne diseases. Drought conditions also favor outbreaks of meningococcal meningitis and cholera.[298]

Neglected diseases

Several of the diseases climate change is likely to spread, such as malaria and dengue fever, are "neglected diseases" that generally receive less pharmaceutical investment and R&D effort. Pharmaceutical companies may face increasing market pressure to boost their drug development efforts in these areas.[299]

Malnutrition

Impacts of climate change, water scarcity, and other environmental trends on crop yields, coupled with population increases, may lead to increased effects from malnutrition.[300]

Trauma

Rising incidence and severity of extreme weather events may increasingly undermine physical and psychological health, with millions of people suffering injuries, disease, long-term disabilities, and emotional anguish.[301]

Allergies

Climate change is expected to lead to increased production of allergens and thus increased incidence of symptoms in those with allergies, increasing demand for health services and drugs to treat those symptoms.[302]

Medications requiring water or controlled temperature

Increasing challenges concerning water quality, water scarcity, and climate change may create market pressure on pharmaceutical companies to develop more medicines for which effectiveness does not require taking them with clean water or transporting and storing them in temperature- and moisture-controlled environments.[303]

Traditional remedies

Biodiversity loss threatens the health and well-being of populations, often in developing countries, that rely on wild medicinal plants, which face a high risk of extinction in those parts of the world where people are most dependent on them.[304] Biodiversity loss is thus likely to negatively affect pharmaceutical industry provision of traditional remedies.[305]

Drug access and pricing

Increasing impacts of climate change, water scarcity, and other environmental trends on manufacturing capacity in India, which currently produces a large percentage of the world's generic drugs, may affect global availability and cost of generics.[306]

Governments are significant purchasers of healthcare in many markets, so increasing negative impacts from climate change and other environmental trends on government finances may lead to reduced government spending on healthcare, which in turn may affect drug prices and sales of (and thus access to) more modern medicines.[307]

Policy Implications

Overall disease burden

Approximately 24 percent of the global disease burden and 23 percent of all deaths can be attributed to environmental factors. Regulations and international treaties restricting air pollution, water pollution, chemicals, mercury, and other environmental problems should help somewhat reduce the disease burden (and demand for healthcare services) attributable to those environmental factors.[308]

Green buildings

Increasing concerns about a range of environmental trends may lead to more regulations requiring hospitals, nursing homes, and other health care facilities that seek to expand or renovate to do so in accordance with green building standards that, among other things, use recycled building materials, reduce energy and water use, limit ozone-depleting refrigerants, and promote alternative transportation options for staff.[309]

Health care facility waste

Rising concerns about pharmaceutical and other chemical contamination of water and air may lead to stricter (or more strictly enforced) regulations on management of healthcare facilities' pharmaceutical wastes and other waste streams, some of which can be highly toxic (e.g., chemotherapy chemicals, solvents).[310] This may include greater restrictions on medical waste incineration, which is a leading source of dioxin, mercury, lead, and other pollutants.[311]

Green medical products

Medical device and supply companies may face regulatory and market pressures to offer more sustainable products (e.g., ones that reduce use of hazardous chemicals) to healthcare providers.[312]

Reputational Implications

Environmental footprints

Healthcare facilities that have taken steps to reduce their environmental footprints (and, simultaneously, improve patient comfort) may see reputational benefits within their communities and be better able to attract patients and staff.[313]

Biodiversity and water

Pharmaceutical companies that source active or inert ingredients from an overexploited species or that extract water without consideration of local community and environmental needs may face reputational damage and restricted future access, particularly if there are conflicts with local communities that rely on the water or use the species for traditional medicine. Companies that rely on inert ingredients such as palm oil that are associated with deforestation and other ecosystem damage may face similar reputational risks.[314]

3.8 Information and Communication Technology

The information and communication technology (ICT) sector – here considered to encompass computer hardware and software, mobile phones, and other electronic information and communications devices – faces some risks but also significant market opportunities from environmental trends and underlying drivers. This sector has obvious ties to virtually every other business sector, some of which enable ICT (e.g., electric power, extractives) and all of which increasingly rely on ICT for a range of needs.

Operational Implications

Energy cost

The ICT sector's energy use is significant and growing. Datacenters are the fastest growing part of its carbon footprint, which is expected to be about 2 percent of global greenhouse gas emissions in 2020. Datacenters can use 100 to 200 times more electricity than a typical commercial office building. This makes ICT companies' operating costs vulnerable to energy price volatility and regulations or taxes targeting greenhouse gas emissions.[315]

Electricity reliability

Increasing power shortages or outages due to a range of environmental trends may disrupt production at ICT manufacturing sites, costing companies millions of dollars in lost material.[316] (See section 3.3 above for more on impacts to the electric power sector)

Water availability and quality

Manufacturing ICT components and products and cooling datacenters both require significant volumes of water. Semiconductor plants, in particular, require large volumes of ultrapure water (which involves an energy-intensive purification process) and are often located in regions of the world at great risk of water scarcity (e.g., Asia, the U.S. southwest). The sector thus faces increasing risk of higher operating costs and disrupted or halted operations (and thus lost revenue) due to water scarcity and water quality concerns.[317]

Minerals and metals

The ICT sector relies heavily on supplies of minerals and metals, including cadmium, gallium, tantalum, and lithium. This exposes the sector to supply disruptions in the mining industry caused by a range of environmental trends.[318] (See section 3.4 above for more on impacts to the extractive sector.)

Business continuity

Extreme weather events and sea level rise associated with climate change can damage or disrupt ICT sector manufacturing operations, data networks, equipment, offices, and other physical assets (e.g., cell towers).[319] The severe flooding in Thailand in October 2011, for instance, seriously damaged and disrupted hard drive manufacturing facilities, leading to lost sales, halted production, and delayed launch of some products – forcing companies to restore and revamp their supply chains.[320] The ICT sector may need to increase investment in more resilient networks, facilities, and other infrastructure.[321]

Silicon Valley in the U.S. state of California – home to Facebook, Google, Intel, and many other ICT companies located along San Francisco Bay – is 3 to 10 feet (roughly 1 to 3 meters) below sea level and already relies on levees to hold back water; sea level rise and a major storm surge could damage and/or overtop the levees, putting ICT companies' buildings and facilities at risk.[322]

Market Implications

Overall demand

Population growth, urbanization, and economic development will create rising demand for ICT products and services such as mobile phones and internet connectivity, particularly in developing countries. Increasing urbanization also opens opportunities for the sector in new "smart" cities with networked systems of services (e.g., traffic).[323]

Extreme weather events and sea level rise associated with climate change can damage or disrupt ICT sector manufacturing operations, data networks, equipment, offices, and other physical assets – e.g., cell towers.

Enabling environmental improvements

As efforts increase to address the various impacts of environmental trends and drivers, the ICT sector is likely to see expanded or new markets for its information-gathering, data-analyzing, systems-integrating products and services to track and improve energy efficiency, water efficiency, and other aspects of environmental performance in many other sectors. It is likely that ICT will increasingly enable sectors to see their resource use and emissions in real time.

ICT companies may see greater demand for services that vastly reduce the amount of water needed in other sectors' (and its own) manufacturing plants. They may see rising demand for smart buildings (e.g., with building energy management systems), smart motors (e.g., with variable speed drives) and process automation in manufacturing, and smart transport and storage logistics systems (e.g., intermodal shifts, route optimization). ICT may see increased demand from agriculture for products and services that enable farmers to more accurately assess how much irrigation and fertilizers their crops require, reduce the amount of land needed for raising livestock, and better predict the weather. ICT may see increased use in tracking hazardous waste transport within and across borders. In the electric power sector, smart grids will rely on ICT to integrate greater amounts of renewable energy, distributed generation, demand management, real-time pricing, and power load balancing, while also reducing electricity losses in transmission and distribution.[324] (See sections 3.1, 3.3 and 3.6 above and 3.10 below for more on impacts to the buildings and construction, electric power, food and beverage, and transportation sectors.)

Displacing traditional goods and services

Increasing concerns about the range of impacts from environmental trends and drivers may create growing market opportunities for the ICT sector to replace other sectors' traditional goods and services with electronic or "virtual" ones. For example, the sector is likely to see increased demand for products and services that enable videoconferencing instead of traveling, teleworking instead of commuting, electronic materials instead of paper-based or other physical products, e-government instead of paper-based and in-person services, and e-commerce instead of constructing, operating, and travelling to stores.[325]

Collecting environmental data

The ICT sector is likely to see increased demand for products and services to better track and assess the state and trends of the environment, including enabling remote and on-site monitoring of environmental change. In addition, the sector may see increasing demand (particularly in emerging markets) for tools to help customers understand, anticipate, evaluate, and integrate measures in preparation for adapting to environmental change, including emergency and disaster warning systems (e.g., the Rio Operations Center in Brazil, developed by IBM) and business continuity and recovery products and services.[326]

Green hardware

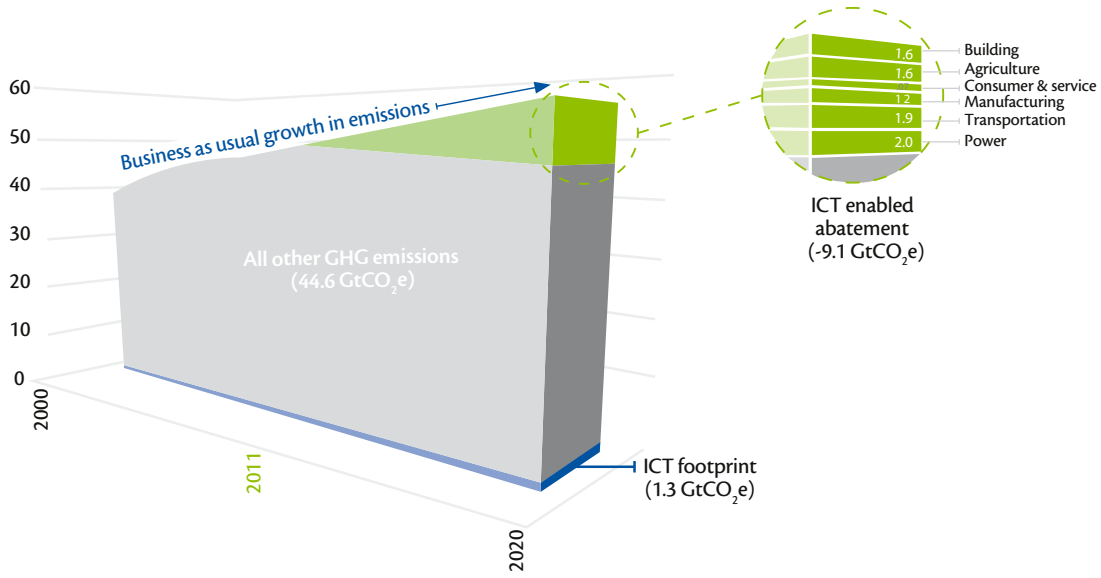
ICT companies may experience increasing pressure from consumers to reduce their carbon and energy intensity and their use of toxic substances – and may see a corresponding rise in demand for more energy-efficient and sustainable "green ICT". ICT companies may similarly see pressure from corporate clients in other sectors that are under pressure themselves to reduce their environmental footprints.[327]

Policy Implications

Greenhouse gas emissions

The ICT sector may face increasing limitations on releases of potent greenhouse gases like SF_6 and PFCs during manufacture, use, and end-of-life of its products.[328]

Abatement potential in 2020 plotted with the direct emissions from the ICT industry and total global GHG emissions



Source: GeSI SMARTer 2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative, 2012

Electronic waste

Rising concerns about the environmental and human health impacts in developing countries of electronic waste, which is the fastest-growing waste stream in the world (estimated at 20–50 million tons total per year), may lead to increasing consumer pressure and regulatory requirements (e.g., Brazil's 2010 National Solid Waste Policy) for companies in the ICT sector to take greater responsibility for waste reduction, reuse, and recycling.[329]

Hazardous waste

Semiconductor plants' wastewater can contain a range of hazardous chemicals, including arsenic, antimony, and hydrofluoric acid. Rising concerns about chemical contamination of water and land may lead to new or stricter regulations (and litigation) requiring companies to better manage hazardous chemicals in their waste streams and to clean up sites already contaminated.[330]

Energy efficiency

Policy actions aimed at reducing greenhouse gas emissions or improving energy efficiency may drive further adoption of ICT. For instance, building codes and other policy measures to improve building efficiency may strengthen the business case for investing in new or improved building energy management systems.[331] (See section 3.1 above for more on impacts to the building and construction sector.)

Reputational Implications

Supply chain impacts on the environment

Given rising concerns about declining environmental trends, the ICT sector may be exposed to reputational risk due to the serious environmental impacts of its sourcing of key materials (e.g., coltan ore mined in the eastern Democratic Republic of the Congo) and the manufacturing of its products (e.g., heavy metal pollution in the water in the Pearl River Basin in the Guangdong region of China).[332]

Waste disposal

Disposal of the sector's rapidly obsolete products poses reputational risks to ICT companies, as the hazardous chemical pollution and resulting health effects from e-waste dumping sites – such as the one in the Agbogbloshie slum outside Accra, Ghana – become more prominent.[333]

Energy

Given the rising energy use of its datacenters, ICT companies may see increasing reputational risks based on the efficiency and sources of energy used to power those centers, with greater consumer and NGO pressure to boost energy efficiency and renewable energy.[334]

Water

The significant water needs for ICT manufacturing and cooling of data centers may create reputational risks for the sector and constrain potential expansion plans, particularly in water-scarce regions.[335]

Environmental solutions

ICT companies recognized as contributing to solving big environmental challenges such as climate change, water quality/availability, and deforestation may see reputational benefits.[336]

3.9 Tourism

The tourism sector is here considered to encompass businesses tied to helping people travel to and stay in places for leisure, business, and other purposes. It faces significant risks and opportunities from environmental trends and drivers, principally because climate, weather, and natural resources are key attributes that make tourism destinations desirable to visit. The tourism sector is also tied to the impacts of environmental trends and drivers on several other sectors – most closely, of course, to the transportation sector (which is considered in this section but is addressed more fully below in section 3.10).

Operational Implications

Energy cost

The tourism sector's consumption of energy is sizable, growing, and dependent on fossil fuels. Tourism travel has been increasing, as has the trend of traveling further via energy-intensive modes of transportation (e.g., airplanes and cars instead of trains). Tourism is responsible for about 5 percent of global greenhouse gas emissions, 75 percent of which is due to transport (including 40 percent from aviation, 32 percent from cars, and about 1.5 percent from cruise ships). Cruise tourism is the most energy-intensive form of tourism on a per-tourist-trip basis. (See section 3.10 below for more on impacts to the transportation sector.) Another 21 percent of the sector's emissions come from tourist accommodations (mostly for heating and air-conditioning). (See section 3.1 above for more on impacts to the building and construction sector.) The tourism sector is thus vulnerable to energy price volatility and regulations or taxes targeting greenhouse gas emissions, which may affect the cost of getting to and providing comfort in tourist areas.[337]

Investments by tourism businesses to reduce energy consumption have been found to generate significant returns within a short payback period.[338] On the other hand, in some cases, efforts by tourism businesses to adapt to changing climate conditions may lead to even higher energy use and operating costs. For instance, warmer winters and declining snowpack may increase operating costs (for both energy and water) for ski resorts that need to boost snow-making efforts (assuming the weather is cold enough), though indoor heating costs may decline. Rising temperatures and increased incidence of heat waves may similarly increase operating costs for accommodation businesses in warm-weather destinations that need to provide much greater levels of air conditioning to ensure indoor comfort.[339]

Local resources

Declining availability of local resources (e.g., water, food) due to a range of environmental trends and drivers can lead to increasing operational costs and the need to import goods and raw materials.[340] (See section 3.6 above for more on impacts to the food and beverage sector.)

Business continuity

Increasing extreme weather events (e.g., storms, floods, wildfires) could physically damage tourism infrastructure and facilities and lead to losses from business interruption.[341] Illustrative of the risks, for instance, is the damage inflicted in December 2012 by Cyclone Evan on hotels, beach resorts, and the international airport in Samoa, including millions of dollars of damage to Aggie Grey's Hotel.[342]

Travel interruption

Increasing extreme weather events associated with climate change could also disrupt travel to tourist destinations. For instance, severe storms in Europe and parts of the United States during the 2010-2011 winter shut down airports and depressed The Walt Disney Company's revenues from parks and resorts in Q1 2011.[343] Storms that winter in other parts of the United States similarly prevented many of Boyd Gaming's customers from visiting its gaming operations, costing the company nearly $3 million in earnings.[344] (See section 3.10 below for more on impacts to the transportation sector.)

Market Implications

Overall demand

Globalization, population growth, urbanization, and economic development, particularly in emerging and developing countries, will create rising demand for the tourism sector, as there will be easier access across borders, more people (especially in congested cities) seeking escapist travel, and rising incomes to enable such travel.[345]

Energy price volatility and rising pressure to reduce emissions (see Operational Implications above) may make the price of air transport more expensive, reducing demand for long-distance travel and thus for the tourism businesses serving those destinations, while potentially increasing demand for tourism businesses with greater access to a local consumer base.[346] Higher costs, among other factors, may also lead to reduced demand from business travellers, who might choose to use videoconferencing instead.[347] (See section 3.7 above for more on impacts to the ICT sector.)

Changes in local environmental conditions

Extreme weather events, long-term impacts of climate change, water scarcity, declining biodiversity, and other changes in environmental conditions can make particular tourist destinations more or less desirable, fundamentally

affecting market demand for companies with ties to those locations. For example:

- Sea level rise and increasing incidence of hurricanes and tropical storms may decrease demand for companies such as beach resorts that promote coastal vacations.
- Warmer winters and melting glaciers may reduce demand for companies that promote cold weather and snow-based activities. Of the 103 ski resorts operating in the U.S. northeast, fewer than half are likely to remain economically viable in 30 years if average winter temperatures increase 2.5° to 4°F.
- Warmer sea temperatures, increased ocean acidification, and declining marine biodiversity may reduce demand for companies that promote activities tied to flourishing coral reefs (e.g., snorkeling, scuba diving).
- Changes in precipitation levels and patterns, droughts, and floods, as well as water quality issues, may affect demand for companies that promote recreational activities tied to lakes, rivers, and snow (e.g., fishing, boating, whitewater rafting).
- A range of environmental trends may affect tourism tied to food and agricultural production (e.g., wine tourism) (see section 3.6 above for more on impacts to the food and beverage sector).

Such changing conditions may force tourism companies, particularly companies reliant on seasonal demand, to shift their primary seasons, change locations, or expand their range of recreational offerings to enable year-round revenue generation. On the other hand, warmer summers and shorter winters may extend tourist seasons in typically colder locations, and declining seasonal Arctic Ocean ice cover may increase demand for tourism in the region.[348]

Extreme weather events, long-term impacts of climate change, water scarcity, declining biodiversity, and other changes in environmental conditions can make particular tourist destinations more or less desirable, fundamentally affecting market demand for companies with ties to those locations.

Ecotourism

As concerns about environmental trends and drivers increase, so too will demand from tourists for nature-based tourism, ecotourism, and other "green" tourism options – for which they may be willing to pay more. This demand may lead more tourism companies, including the small and medium-sized tourism-related enterprises that make up the majority of the sector, to improve sustainability performance and offer green tourism options in order to remain competitive. Increasing consumer demand for tourism experiences that involve wildlife, pristine or near-pristine ecosystems, or places that may change or disappear due to climate change may both increase the environmental impacts of tourism in those places and drive the sector to enhance efforts (including public-private partnerships) to protect sensitive ecosystems.[349]

Agro-tourism

Efforts to protect biodiversity and water quality in agricultural settings may lead to increased or restored field margins, which may enhance agro-tourism demand.[350]

Policy Implications

Local resource use and development

Rising concerns about biodiversity decline, habitat loss, water scarcity, vulnerability to climate impacts, and other environmental trends may lead to new or expanded regulations (e.g., zoning ordinances, environmental rules) that restrict or alter some current sector practices, including fishing off of coral reefs, sewage dumping, development in coastal mangroves, and water use by golf courses.[351]

Cruise pollution

Increasing concerns about air and water pollution may lead to new or stricter regulations concerning cruise ships in ports and harbor towns and near coasts, increasing costs for cruise ship operators.[352]

Reputational Implications

Water consumption

The tourism sector can be the major user of water in some water-scarce countries and regions (e.g., small islands), utilizing water for golf courses, irrigated gardens, swimming pools, guest rooms, and other purposes. This can put pressure on already scarce local water supplies, compete with other local sectors, threaten the subsistence needs of local populations, and result in stark inequity between the water use of tourists and neighboring communities – thus creating reputational risks (and high water costs) for the sector.[353]

Land use

Similarly, to the extent that tourist facility development involves building over agricultural land (e.g., for new golf courses or hotels), tourism companies may face community opposition and reputational risk as competing pressures on land – particularly arable land – increase.[354]

Biodiversity

High-volume tourism has often had detrimental effects on biodiversity – including coral reefs, coastal wetlands, and rainforests – due to pollution, land-clearing, and other impacts. Companies that fail to incorporate biodiversity concerns into destination planning, investment, and operation may not only reduce the value-creation potential of the destination, but also experience increased conflicts with local communities and increased reputational harm.[355]

In contrast, tourism companies that improve their environmental practices can see reputational and marketing benefits. For example, Exodus, an adventure tour operator based in the United Kingdom, has seen increased bookings, positive publicity in the media, and greater industry recognition since adopting a Responsible Tourism Policy in 2000.[356]

Companies that fail to incorporate biodiversity concerns into destination planning, investment, and operation may not only reduce the value-creation potential of the destination, but also experience increased conflicts with local communities and increased reputational harm.

3.10 Transportation

The transportation sector – here considered to encompass goods shipments (air, rail, marine, road) and passenger transport (automotive, rail, air), but not public transit (except as it may impact the private sector) – resembles the electric power sector in that it is fundamental to modern society, underlies virtually all other sectors, has significant resource needs and impacts, relies on extensive infrastructure, and is inextricably tied to climate change causes and solutions. The transportation sector is exposed to serious risks as well as some opportunities from environmental trends and their underlying drivers.

Operational Implications

Fuel cost

The global transportation system currently runs almost entirely on petroleum products. Transport consumes more than half of global liquid fossil fuels now and is expected to account for nearly all of the increase in global primary oil use through 2030.[357] The profitability and costs of those parts of the transport sector that operate vehicles and vessels – such as trucking, shipping, and airline companies – are heavily tied to the price of oil. Accordingly, these companies, which tend to have thin margins, are vulnerable to fossil fuel price increases and supply fluctuations (e.g., from constraints or costs on fossil fuels imposed by climate-related policies). Those companies that are most fuel-efficient and best able to incorporate cleaner fuels may therefore see a competitive advantage.[358]

At the same time, companies relying increasingly on biofuels may face price increases and supply fluctuations due to environmental trends (e.g., droughts) affecting crop production.[359]

A warmer climate may also increase energy costs associated with cold storage and refrigerated transport.[360]

Materials supply

The transportation sector relies heavily on supplies of certain raw materials (e.g., metals, rubber), as well as a range of other supplies, that may be disrupted by extreme weather events and other factors (see, for example, section 3.4 above for more on impacts to the extractive sector), which may increase companies' costs, create delays or temporary shutdowns, and lead to loss of business, contracts, and customers.[361]

Water availability

Manufacturing automobiles requires large amounts of water, which means increasing water scarcity in some regions (and the accompanying increased competition for and regulation of water) may raise operating costs for companies that do not adapt by, for example, instituting water recovery and reduction systems.[362]

Business continuity

Extreme weather events, rising sea levels, droughts, and other climate-related weather conditions will likely have impacts – both immediate and long-term – on the transportation sector's day-to-day operations, vehicles, and infrastructure. Rising sea levels and storm surges may affect the ability to travel across and under bridges and could damage ports, airports, and other coastal infrastructure and facilities. Extreme storms and wildfires could temporarily close ports or transport routes and damage infrastructure, vehicles, and facilities. Storms and higher winds can make travel more hazardous, increasing accidents and delays. Droughts and floods can disrupt freight travel on rivers. Heat waves and thawing permafrost can cause damage to rails, roads, bridges, and airports. Wandering "ice islands" calved from Greenland's glaciers, which will likely increase in number in a warming world, could potentially wander into shipping lanes, endangering marine transport.

On the other hand, higher temperatures may reduce the impacts of freeze-thaw cycles, lower the costs of snow removal, and increase the number of frost-free days for ports and waterways in some colder climates.[363]

Transportation companies and assets in locations highly vulnerable to climate impacts may experience loss of insurance coverage. In addition, much of the vulnerable transportation infrastructure is owned by governments, increasing the challenge of ensuring more climate resilient systems.[364]

Cargo payloads

Increased incidence of extreme heat waves may impact air cargo operators, as extreme heat affects aircraft lift (particularly at high-altitude airports). If runways are not long enough, aircraft cargo payloads would have to be reduced (or flights cancelled). For instance, it is estimated that a Boeing 747 at the Denver and Phoenix airports in the U.S. would face 17 and 9 percent summer cargo loss respectively by 2030 due to increased temperatures and water vapor.[365]

Market Implications

Overall demand

The GDPs of India and China are expected to approach or exceed that of the United States by mid-century. Countries and regions are specializing (i.e., focusing on production

of particular goods) in attempts to become economically competitive, while climate change may shift the nature and locations of agricultural production, resource extraction, and tourism travel (see sections 3.4, 3.6, and 3.9 above for more on impacts to the extractive, food and beverage, and tourism sectors). This confluence of factors will have fundamental implications for world trade, the global flow of goods, corporate logistics and supply chains, and the performance of existing transportation facilities (and the need for new ones) – and may significantly increase demand for transport.[366]

Trucking is expected to lead the growth in freight transportation demand for fuels in developing countries, while carbon emissions from shipping may more than double by 2050. Aviation demand is expected to grow exponentially.[367] Congestion will likely increase at major ports and airports, resulting in delays, higher costs, and more pollution.[368] Some current efforts to reduce emissions from shipping, such as wider adoption of slow-speed steaming, might be reversed in order to better meet soaring demand – demand levels that may strain existing ports and harbors.[369]

In addition, population growth, urbanization, and economic development in developing countries will lead to growth in demand for individual motorized vehicles. The number of motor vehicles is already growing much faster than the number of people in the world, especially in nations such as India and China. On a business-as-usual path, the global vehicle fleet is expected to grow from about 800 million to 2-3 billion by mid-century, with most of the growth in developing countries.[370]

Developing countries concerned about air pollution, congestion, and infrastructure limits may create new cities that are effectively car-free, see existing cities institute more restrictions on the issuance of car licenses, or advance other urban planning initiatives that will affect demand growth for the sector.[371]

Fuel efficiency and clean fuels

As noted above, the global transportation system runs largely on petroleum products.[372] Accordingly, fossil fuel price and supply fluctuations can shape consumer demand – in terms of overall volume and vehicle preferences – for those parts of the transport sector that produce vehicles and vessels. Concerns about urban air quality and climate change are likely to further increase market pressure for vehicle and vessel manufacturers to improve efficiency and shift to cleaner fuels to power their vehicles, including natural gas, second-generation biofuels, hydrogen, and electricity.[373] At the same time, energy price volatility may lead to increased demand for shipping compared to other less-efficient forms of transport.[374]

Substitutes for conventional transportation

Concerns about urban air quality, climate change, and energy price volatility may also lead to increasing use of teleconferencing, telecommuting, car-sharing, public transit, bicycles, and other substitutes for conventional transport, thereby somewhat reducing demand for some companies in the transportation sector while simultaneously creating new opportunities for others (e.g., car-sharing companies or companies that manufacture public transit vehicles).[375] In addition, these concerns may open business opportunities for transportation companies to respond to demand from consumers in other sectors seeking a reduced logistics and supply chain sustainability footprint.[376]

More broadly, increasing urbanization and the range of associated transport-related environmental concerns may lead to a substantial shift in the automotive business model in the near future, from the current model focused on vehicles to a new model that provides multiple ways of achieving sustainable personal mobility.[377]

Arctic shipping

Climate change is likely to lead to opening of Arctic shipping routes and broader development of Arctic resources, which suggests the region will represent a growing market for shipping companies, while increasing the risk of environmental damage to fragile ecosystems.[378]

Policy Implications

Air pollution

The transportation sector is a significant source of emissions of sulfur, particulate matter, nitrogen oxides, black carbon (soot), and many other pollutants. Transportation generates more than 80 percent of the air pollution in developing country cities. In many places, the sector is already subject to a range of regulations that restrict fuel and vehicle emissions. Increasing concerns about air quality, water systems, and human health – as well as, with respect to black carbon, climate change – may lead to increased regulatory efforts and other initiatives (especially, perhaps, in Asia) to reduce the sulfur content of diesel fuels, nitrogen oxide emissions from road transport, and a range of emissions from shipping and ports (including through the International Convention for the Prevention of Marine Pollution from Ships (MARPOL) and the International Maritime Organization (IMO)). Compliance with these regulations may add complexity and cost for transportation companies.[379]

Greenhouse gas emissions

Regulations designed to reduce greenhouse gas emissions can have significant impacts on the transportation sector, as the sector's fossil fuel reliance contributes about 25 percent of global energy-related carbon dioxide emissions, a contribution that is expected to increase by 1.7 percent per year through 2030.[380] The sector is already subject to

Developing countries concerned about air pollution, congestion, and infrastructure limits may create new cities that are effectively car-free, or advance other urban planning initiatives that will affect demand growth for the sector.

a wide range of regulations (mostly in developed countries and China), including vehicle fuel economy standards, greenhouse gas emission standards, and carbon taxes, which can increase costs, shift consumer demand, and influence product design. Such regulations will only grow more restrictive and more widespread in developing countries as climate concerns increase.[381]

Airlines and shipping companies may see increased greenhouse gas regulation either from their respective international organizations (ICAO and IMO) or, absent a global approach, a patchwork of regulatory measures from individual governments – either of which could spur early scrapping of older vehicles and vessels.[382] At the same time, governments are instituting regulations and incentives to stimulate market adoption of cleaner transportation options, creating opportunities for companies to meet that new demand.[383]

Biodiversity

As concerns about biodiversity and invasive species increase, shipping companies can expect increased regulations requiring ballast water treatment to kill invasive organisms, building on the IMO's 2009 regulations.[384]

Increasing concerns about protecting ecosystems with high biodiversity value may result in more regulatory denials of proposed expansions of transportation facilities (e.g., ports, airports). Such permit denials may force companies to write-off expenditures invested in the proposals and lead to potential drops in share price.[385]

End-of-life disposition

Concerns about waste streams and resource scarcity may lead to increased regulatory focus on end-of-life treatment for transportation sector vehicles (e.g., ship breaking and recycling) and their components (e.g., electric vehicle batteries).[386] More broadly, increasing pressure on global resources may lead to increased regulatory focus on promoting 'closed loop' processes that re-use and recycle resources.[387]

Reputational Implications

Fuel/food/forests

Rising concerns about climate change (and energy security) may lead to transportation companies increasing incorporation of biofuels into their fuel supplies. Increased biofuel production has the potential to increase conversion of forests and food cropland, which can have a range of environmental and food price impacts – and thus may lead to reputational risk for transportation companies via increased political and consumer pressure to minimize biofuel use or ensure protection of forests and food cropland.[388]

Climate change

Rising concerns about climate change create reputational risks for transportation companies not seen as doing their part to contribute to solutions – and reputational opportunities for those seen as leaders taking on their fair share. Companies may increasingly see reputational benefits from visibly applying credible science to business decision-making and corporate goals. For instance, Ford's technology plans are predicated on an analysis of what the company's fair share of carbon dioxide emission reductions from light-duty vehicles should be to stabilize atmospheric concentrations at 450 ppm.[389]

4. Conclusion

GEO-5 paints a daunting picture of the state and trends of the global environment. Degradation is occurring in many ecosystems and is visible across numerous environmental indicators. While there are some bright spots, absent major policy shifts and transformative change through concerted action from governments, businesses, and others, we can expect that the state of the environment will generally worsen over both the short and the long term.

For those who still wonder why business should act, this report should make clear that, in every industry sector, changes in the global environment put business value at stake. The report also makes clear that the risks and opportunities vary from sector to sector. While there is little in this report that on its own is new, the cumulative picture is compelling: in every sector, and in a myriad of ways, the impacts of changes in the environment on businesses are numerous, material, and imminent.

While the challenges are many, forward-thinking companies – in many sectors and across geographies – are gaining competitive advantage by understanding environmental trends and taking action.

The Path Forward

The environmental landscape is changing. As a consequence, the business landscape is also changing. How can business leaders ensure that the risks and opportunities posed by environmental trends are understood, addressed, and turned to their competitive long-term advantage? We offer the following recommendations:

- **Translate from general to specific.** The impacts identified in this report are most useful to individual companies when thought of as categories of potential impacts. The next step is to apply this report to your company's particular business model, geographic presence, operations, supply chain, products, and customers. Taking a life-cycle approach, determine how environmental changes will affect your business (e.g., rating/ranking the relevance of specific impacts). Done well, such an analysis will clarify the specific risks and opportunities your company faces.
- **Mitigate AND adapt.** It remains critically important for companies to minimize their negative impacts on the environment. The more effective the mitigation, the less severe the necessary adaptation and the potential regulatory burden will be. Continue to seek opportunities to reduce your company's environmental impact – across the life cycle. Such reductions can also improve operating efficiencies, reduce liabilities, and enhance company reputation.
- **Think strategically.** Adapt your business strategy to be well-positioned for the environmental changes ahead. Integrate information on environmental trends into business planning for product development, operations, marketing, external affairs, and other functions
- **Be transparent.** Stakeholders – including investors, employees, customers, communities, and NGOs – expect an increasing level of transparency from companies. Report regularly to your stakeholders about your company's impacts on the environment, as well as the risks and opportunities posed by environmental trends. Describe your strategies for both mitigating impacts and positioning for changing conditions, as well as recent performance and future objectives. In addition to meeting the needs of stakeholders, transparency

In every sector, and in a myriad of ways, the impacts of changes in the environment on businesses are numerous, material, and imminent.

and reporting can drive internal improvement in numerous ways.

- **Influence policy.** Public policy plays an important role in addressing environmental trends. But companies should not simply wait for governments to take action. Engage with legislators and regulators to shape policies that enable and reward progressive strategies and strong environmental performance.
- **Collaborate for more powerful solutions.** The challenges created by changes in the environment are too big for one company to solve. Identify organizations – governments, NGOs, competitors, suppliers, customers – that have a shared interest in addressing the challenges, and together explore how you might collaborate on solutions. Then establish agreements that leverage the strengths of each organization to achieve your common goal.

The impacts of environmental trends on business are no longer future concerns. They are affecting companies today, both positively and negatively. Those businesses that understand environmental trends and consider them in their business strategies will likely be better positioned for a prosperous future.

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