FGWPro® 2023 Study Notes

STUDY NOTES FOR THE GARP SUSTAINABILITY AND CLIMATE RISK

Content

FOREWORD

This book will be a valuable addition to the study tools of any GARP Sustainability & Climate Risk exam candidate. It delivers a concise and lucid explanation of the key components of the GARP Sustainability & Climate Risk curriculum. Our aim has been to incorporate LOS that pertain to essential concepts in sustainability and climate risk, are applicable to other LOS, are intricate and challenging for candidates, necessitate memorization of characteristics or relationships, or serve as a foundation for subsequent levels.

We encourage candidates to utilize this publication in tandem with their other comprehensive study materials. The compact nature of this book facilitates ease of transport, thereby enabling candidates to repeatedly review the critical concepts, definitions, and methodologies—an essential aspect of mastering the content. Should candidates encounter topics that too brief or raises questions in your mind, they are advised to consult their GARP Sustainability & Climate Risk curriculum to address any deficiencies in comprehension. While no shortcuts exist for mastering the vast array of subjects encompassed by the GARP Sustainability & Climate Risk-centric curriculum, this volume shall serve as a crucial instrument for learning and reviewing material throughout the study period leading up to the examination.

it is crucial not to underestimate the challenge ahead. Our Sustainability & Climate Risk -centric study materials, practice exams, question bank, study notes, quick sheets and videos are all designed to help you study as efficiently as possible, grasp and retain the material, and apply it confidently on exam day.

CHAPTER 1

Climate Change

The surface temperature record indicates that **Earth has experienced a 1.1°C warming** during this period, calculated as the difference between the average temperatures of 1850-1900 and 2009-2018. As of early 2022, the hottest year on record was 2016, followed by 2020, 2019, 2017, and 2015. The warming hasn't been evenly distributed—**land has warmed more than oceans**, and the **northern hemisphere has warmed more than the tropics or the southern hemisphere**. This is significant because approximately 85% of the global population resides on land in the northern hemisphere, meaning they have experienced greater warming over the past 150 years than the worldwide average.

Various independent scientific groups, such as NASA, NOAA, and the UK Hadley Center, have created their own surface temperature records from raw station data, all of which display similar warming trends. In the interest of transparency, several of these groups have publicly released the code and data used to generate their warming estimates. About **93% of the heat trapped by greenhouse gases is absorbed by the oceans**, so we can also examine whether energy or heat is accumulating in them (IPCC, 2013). The heat content of the top 2 km/1.25 miles of the ocean reveals that the **oceans are indeed gaining energy.**

Furthermore, sea levels are rising linearly. **Two primary factors** contribute to sea level rise:

- **the melting of grounded ice**;

- **the thermal expansion of water due to ocean warming**.

As grounded ice melts and the water flows into the ocean, the total volume of water in the ocean increases, causing sea levels to rise. Current research indicates that we are losing grounded ice on Earth, which is expected to drive sea level increases. Additionally, as the oceans warm, water expands, leading to further sea level rise. Over the past century, these two processes have contributed approximately equally to the rising sea levels.

In order to gain perspective on today's warming, it is important to examine the Earth's climate history. However, since the measurements from the previous section only cover the past 170 years, alternative methods are necessary to look further back in time without relying on thermometer data. This can be achieved by using long-lived **geological, chemical, or biological systems** that have recorded past climate conditions. By measuring these systems today, we can gain insight into what the climate was like in the past.

Some examples include:

- **Tree rings**, which can expose climate changes in regions with trees that undergo seasonal changes for up to a millennium.

- **Corals**, whose skeletons can be analyzed to uncover climate conditions in the ocean over millions of years.
- **Speleothems,** such as stalactites and stalagmites found in caves, which can provide estimations of the climate in the vicinity of the cave over the past few hundred thousand years.
- **Ice cores**, predominantly from Greenland and Antarctica, can provide estimates of the climate over the past million years or so by analyzing the chemical composition of ice.
- **Ocean sediment cores** can reveal information about the climate spanning tens of millions of years by examining the composition of mud at the bottom of the ocean.

The Earth's temperature of the last 410,000 years, indicating that the planet has cycled between **ice ages and warmer interglacial periods** approximately every 100,000 years. **The last ice age ended 10,000 years ago**, ushering in the current interglacial period known as the **Holocene**, during which temperatures peaked around 7,000 years ago and then began a slow decline until the Little Ice Age 200 to 300 years ago. **Since then, the Earth has been warming**, and in the late 2010s, temperatures were about 1°C warmer than during the Little Ice Age. These historical climate estimates lead to several important conclusions about today's warming. For instance, the Earth's global average temperature **difference between an ice age and an interglacial is about 6°C,** so the 1°C warming the planet has experienced since the nineteenth century is significant.

Additionally, human civilization, with its large cities and extensive infrastructure, has only existed since the industrial revolution, and the range of global temperatures experienced during this time has been small. Furthermore, the current warming trend is happening rapidly, with the warming over the past century being approximately **16 times faster** than the average rate of warming that occurred coming out of the last ice age.

Causes Of Climate Change

The Earth's climate is powered by the **Sun's visible radiation**, which provides **340 W/m2 of energy to the Earth**, with **30% reflected back by clouds and other reflective elements of the climate system**. Thus, **the net solar energy absorbed by the Earth is 238 W/m2**. Joseph Fourier noticed in the 1820s that the Earth must be radiating an equal amount of energy back to space. This principle is known as **energy balance**, which states that the energy reaching the Earth must be equivalent to the energy the Earth emits back to space, and this determines the temperature of the climate system.

The Earth's temperature is not solely determined by its own heat production, but also by the composition of the atmosphere, specifically the presence of **greenhouse gases**. **These gases absorb infrared radiation**, which reduces the amount of energy the Earth radiates into space, resulting in a greenhouse effect that increases temperatures. The greenhouse effect was first recognized by scientists such as Joseph Fourier in the 19th century and requires a specific composition of the atmosphere to occur, with the most important greenhouse gases **being water vapor and carbon dioxide. Carbon dioxide's** strong contribution occurs despite the fact that it made up only 0.0415% of our atmosphere in 2020. This is an awkwardly small number, so the concentration is usually written as 415 parts per million (ppm), meaning that, in every million molecules of air, about 415 molecules are CO2.
The majority of the Earth's atmosphere consists of molecules like **nitrogen, oxygen, and argon**, which do not interact with infrared radiation and do not contribute to the greenhouse effect.

Since the mid-twentieth century, the abundance of **carbon dioxide** in the atmosphere has been directly monitored, and the measurements have been plotted in the Keeling Curve. The trend of the curve shows a clear long-term upward trend, indicating that the climate is warming as a result of the

increase in carbon dioxide. This increase is **primarily due to the burning of fossil fuels**, as confirmed by multiple data sources. About **44% of the carbon dioxide that humans release into the atmosphere each year remains in the atmosphere**, and **the rest is absorbed by the ocean or land biosphere**.

The increase in atmospheric carbon dioxide each year is a fixed fraction of what humans emit, providing evidence that **the increase is due to human activities**. The isotopic composition of atmospheric carbon dioxide also shows that the increase is from **fossil fuels, volcanoes, etc.** By examining air bubbles trapped in glacial ice, scientists have determined that the amount of atmospheric carbon dioxide was about 280 ppm in the late-eighteenth century and had increased by 135 ppm or approximately 45% by 2020.

Water vapor and **carbon dioxide** are not the only greenhouse gases that trap heat; **methane** is also a potent greenhouse gas, with a global warming potential (GWP) of 28, which means that **reducing emissions of one tonne of methane is better for the climate than reducing one tonne of carbon dioxide**. Human activities are also increasing the abundance of other powerful greenhouse gases like **nitrous oxide, halocarbons, and ozone**. Humans also generate **aerosols**, such as **sulfate**, **black carbon, and mineral dust**, **which have a cooling effect** on the climate by reflecting incoming solar radiation back into space.

The increased abundance of these aerosols over the past two centuries has **partially offset the warming effect of greenhouse gases**, but they also have negative impacts on human health and the environment. Fossil fuel burning, agricultural activities, and industrial practices are some of the human activities that generate aerosols.

Species	Atmospheric Lifetime	Global Warming Potential (GWP)	Increase in Abundance Since Pre-Industrial	Fraction of Total Greenhouse Radiative Forcing
Carbon dioxide	500 years	1	130 ppm	56%
Methane	12.4 years	28	1.1 ppm	15%
Nitrous oxide	121 years	265	75 ppb	5%
Halocarbons	Years to millennia	100s to 1000s	A few ppb	11%
Ozone	Weeks to months	N/A	Tens of ppb in the upper troposphere	12%

Source: SCR Certificate (2023)

Over the past 250 years, human activities have caused significant changes to radiative forcing, which measures the difference between the amount of incoming energy from the sun that the Earth absorbs and the amount of outgoing energy emitted back into space as infrared radiation.

Carbon dioxide and other greenhouse gases **have caused a positive change** to radiative forcing of about 3.6 w/m2, while **aerosols have caused a negative change** of about 1.1 w/m2. When other small forcings are included, the net human contribution to radiative forcing is a positive 2.7 w/m2.

Water vapor, its abundance in the atmosphere is regulated by evaporation and condensation, which is determined by the Earth's temperature. However, as **the Earth warms, the amount of water vapor in the atmosphere increases**, leading to additional warming through a process called the **water vapor feedback**. This feedback mechanism can double or even triple the amount of warming caused by carbon dioxide alone. Therefore, although water vapor does not directly contribute to radiative forcing, it plays an important role in amplifying the effects of other greenhouse gases.

There are several **natural processes that can impact the Earth's climate**, such as **tectonic processes, output of the sun, orbital variations, and unforced variability.**

Tectonic processes involve the movement of continents which can alter the arrangement of the Earth's surface, leading to changes in climate over millions of years.

Output of the sun has been directly measured since the 1970s and shows no long-term trend that could explain rapid warming in the last two centuries.

Orbital variations are responsible for ice ages, but do not change much over a century.

Unforced variability refers to the Earth's complex internal physics causing climate changes, but it is not likely the cause of modern warming. Instead, the increase in greenhouse gases, such as carbon dioxide, is supported by evidence and the laws of physics. Humans are adding carbon dioxide to the atmosphere, and changes in greenhouse gases have been associated with changes in climate throughout the geologic record.

It is **beyond doubt** that humans are warming the climate system. The likely range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C.
Because the observed warming over this period is about 1.1°C, the best estimate is that humans are responsible for 100% of the observed warming of the climate system. The IPCC uses a set of carefully defined terms to express confidence. In the parlance of the IPCC, likely denotes a confidence of 66% (IPCC).

The Integrated Assessment Modeling Consortium has developed **five different shared socioeconomic pathways (SSPs)** that represent **possible futures** for the next century or two. These pathways are mainly distinguished by the amount of economic growth and climate-safe energy deployed, resulting in different amounts of carbon dioxide emissions into the atmosphere each year. Using emissions scenarios, atmospheric carbon dioxide concentrations can be calculated, and the resulting amount of climate change can be estimated using global climate models (GCMs).

- **SSP1** is a sustainable world where renewable energy is widely adopted, and emissions peak and decline throughout the century, leading to a temperature increase of 2°C/3.6°F above pre-industrial levels.
- **SSP2** follows current trends with declining emissions due to adoption of renewable energy at a slower rate than SSP1, leading to a temperature increase of 3°C/5.4°F above pre-industrial levels.
- **SSP3** is a world where economic inequality leads to slow adoption of new energy technology, leaving the world heavily dependent on fossil fuels and leading to a temperature increase of 4.5°C/8°F above pre-industrial levels.
- **SSP5** is similar to SSP1 but prioritizes economic growth over sustainability, leading to a temperature increase of 5.5°C/10°F above pre-industrial levels. It is uncertain which emissions trajectory the world will follow, and current trends suggest SSP2 is the closest match. However, future decisions could significantly alter our climate trajectory, with consequences for current and future generations.

Impacts of Modern Climate Change

Precipitation

Precipitation is a crucial component of climate, and as temperatures rise, the rate of evaporation at the surface increases, leading to an increase in total global precipitation. However, the increase will not be evenly distributed, and wet regions are likely to become wetter, while dry regions become drier. There will also be an increase in heavy downpours, leading to more flood events, and longer dry periods, causing droughts. The change in precipitation form, such as less snow and more rain in winter, will alter the timing of runoff, reducing freshwater availability and hydroelectric power. These changes will require costly new infrastructure to protect against floods and droughts and exacerbate political tensions over access to water.

Sea Level & Ocean Acidification

The melting of ice is the main driver of rising sea levels, and as a result, the amount of water in the ocean increases, causing **sea levels** to rise. Sea levels are already rising and will continue to rise into the next century. Even a small rise in sea levels could have significant impacts, such as flooding coastal areas and damaging infrastructure. The IPCC predicts that sea levels will rise 44 to 76 cm above today's levels by 2100 under the most likely emissions scenario. Sea-level rise is only a fraction of how much rise we are committed to. A few degrees of warming this century could commit us to many meters of sea-level rise. **Ocean acidification** is another consequence of carbon dioxide emissions, which makes oceans more acidic and could have harmful effects on ocean ecosystems, such as making it harder for calcifying species to build and maintain their shells and skeletons.

Extreme Events

While changes in average climate conditions are important, **extreme weather** events can have significant impacts. Climate change is only one of the contributors to extreme events, which are often random in time. However, **extreme event** attribution science can now help us quantify the contribution of climate change to these events. This science uses three methods: statistical analysis of historical climate, understanding the physics of the phenomenon, and computer simulations of climate. If simulations show that a particular extreme event rarely or never occurs in a world without climate change but does occur in a world with climate change, then it can be attributed to climate change. Attribution studies have found that climate change is already making many extreme weather events more extreme. For example, **Hurricane Harvey's rainfall** was estimated to have been increased by 15% due to climate change. The American Meteorological Society reviews extreme events annually and has found that most of them have been affected by climate change.

The Albedo Effect, Polar Amplification, and Positive Feedbacks Similar

The albedo effect is a process where a decline in sea and land ice can amplify global warming beyond the release of GHGs. This is because ice has a higher albedo or reflectivity than the darker ocean or land, so as ice melts, previously ice-covered areas absorb more solar radiation, heating up the atmosphere, which in turn, melts more ice, exposing more dark areas and reducing the Earth's overall albedo. The Arctic and Antarctic regions are warming faster than other areas of the Earth because of this **polar amplification effect**, which is compounded by other polar and geographic characteristics.

The effects of this amplification are manifold and include faster melting of the Greenland ice sheet, leading to sea level rise, and the release of GHGs such as methane from melting permafrost. These self-reinforcing warming phenomena are called **positive feedbacks**, which accelerate warming. Feedback loops can play an important role in climate tipping points.

Impacts on Human Society and Natural Ecosystems

The impacts of climate change will affect both human society and natural ecosystems, with natural systems being more difficult to manage. These ecosystems, such as mangrove forests and bees, provide many benefits to society, but as they are affected by climate change, these benefits may disappear, shifting costs onto society. Climate change may not warm linearly as greenhouse gases are added, and instead may shift to an entirely new state, known as a climate tipping point. Possible tipping points include the shutdown of the Gulf Stream, disintegration of ice sheets, release of greenhouse gases from permafrost and methane hydrates, and changes to seasonal rainfall on which many people rely. While the probability of a tipping point occurring is difficult to assess and some experts view it as low, if it were to occur, it could have catastrophic effects on both human and natural systems due to the rapid rate of change.

Policy Responses

Adaptation

Adaptation is an essential response to climate change, as it is inevitable that some degree of climate change will occur even with the most optimistic emissions scenario. Adaptation primarily involves **responding to physical climate risk**, which can take various forms, such as building human-made infrastructure or enhancing ecosystem services to protect against storm surges or improving water quality. It can also include better communication, processes, and regulations. While individuals will naturally adapt to the changing climate, effective adaptation responses often require significant resources and large-scale societal coordination.

Thus, **governments must play a significant role** in organizing decisions about large-scale infrastructure and providing resources to support adaptation efforts.

Maladaptation, where an intended adaptation action actually increases climate vulnerability, is a significant concern. The ability of societies to adapt to climate change varies, with financially stable and well-governed countries better positioned to adapt than less financially stable ones. This presents a tension, as the wealthiest countries responsible for climate change are also the most capable of adapting, while the poorest countries, who have contributed the least to the climate problem, will be the most impacted. Governments can help facilitate adaptation by providing reliable information about climate change and technical assistance to help communities and individuals adjust to a changing climate.

Mitigation

Mitigation involves reducing the amount of greenhouse gases, such as carbon dioxide, released into the atmosphere to prevent climate change. Most energy comes from burning fossil fuels, with coal having the highest carbon intensity, followed by oil and natural gas.

Natural gas has been proposed as a cleaner fossil fuel than coal, but methane leakage during extraction or transportation raises questions about its value in reducing emissions. To tackle climate change, we need to replace fossil fuels with climate-safe energy sources that do not release carbon dioxide into the atmosphere.

Solar energy has the most potential, but wind energy is also an important contributor to our energy supply. The primary issue with wind and solar is their intermittency, so we need dispatchable carbon-safe energy sources that can generate energy regardless of weather conditions.

Hydroelectric power is the most widespread dispatchable renewable energy source, but it is unlikely to be greatly expanded due to environmental and political opposition.

Nuclear energy is another significant source of dispatchable and climate-safe energy, but it faces opposition due to concerns about environmental risks, nuclear waste, and proliferation. Advances in small modular reactors hold the promise to address some of these concerns, making nuclear energy more feasible.

Building new nuclear power plants in the United States has been limited due to their high cost and environmental risks, including the potential for nuclear radiation release from accidents or terrorism. Nuclear waste, which is highly radioactive, must also be safely stored for tens of thousands of years to prevent harm to humans and the environment. There is also concern about the possibility of bomb-grade uranium or plutonium being diverted during the fuel cycle to build nuclear weapons. Small modular reactors (SMRs) offer a potential solution to some of these problems, as they are physically smaller and simpler than traditional nuclear power plants, and are expected to have safer modes of failure. However, whether or not these advances will make nuclear energy more politically acceptable is yet to be seen.

Geothermal energy, which involves pumping water heated by the Earth to the surface to generate power, could potentially become a significant source of dispatchable power.

Biomass energy, which involves burning plants for energy, has been used for centuries but presents challenges in terms of land use and environmental impact.

Carbon capture, utilization, and storage (CCUS), which involves capturing carbon dioxide generated from fossil fuel burning and storing it underground, is a promising option, although its economic feasibility remains uncertain.

Short-term energy storage through **batteries** can help balance out the intermittency of solar energy, but longer-term storage is not currently feasible at scale. **Battery production** involves ethical supply chain issues, and efforts to recycle batteries are expected to increase.

Electrification of economic activities is necessary to reach a zero-emission economy, but some processes, such as long-distance trucking and international flights, may require hydrogen energy, which comes with challenges in storage and infrastructure.

The Paris Agreement aims to keep global temperature increase "well below 2°C above pre-industrial levels" and to limit it to 1.5°C. Each country has submitted a nationally determined contribution (NDC) to reduce global emissions. However, these commitments are not enough to limit warming to 2°C. To stay below the 2°C and 1.5°C thresholds, emissions need to decline immediately and reach zero in 2080 and 2050, respectively. Even with these reductions, negative emissions will be necessary, which means removing hundreds of billions of tonnes of carbon dioxide from the atmosphere. The ability to generate large negative emissions is entirely speculative, but it may be necessary to achieve either temperature target.

Geoengineering

Geoengineering is a proposed solution to mitigate climate change. It involves actively manipulating the climate system to prevent further global warming.

The two main categories of geoengineering are

- **solar radiation management**
- **carbon dioxide removal**

The former aims to reduce the amount of **solar energy** absorbed by the Earth, often by injecting sulfur into the stratosphere to reflect sunlight back to space. However, this approach may have **side effects**, such as **changes in precipitation patterns and political conflicts**.

Carbon dioxide removal, on the other hand, involves rapidly removing carbon dioxide from the atmosphere. This can be done through planting trees or by capturing carbon dioxide from the free atmosphere or the exhaust gas of a power plant. However, the scale required to make a significant impact is enormous, and the cost may cause problems in the economy.

BULLET POINTS:

- The term **weather** pertains to the precise state of the atmosphere in a particular location and time.
- **Climate** denotes the extended patterns or data of the weather.
- While temperature is the frequently mentioned quantity when discussing climate, there are numerous other variables, such as precipitation, humidity, cloud cover, visibility, and wind, that contribute to the comprehensive understanding of the climate.
- **Climate change** characterizes the long-term differences in weather statistics measured over decades.
- Although **climate change** is occasionally called global warming, the term global warming can be misleading as it only indicates temperature increase, whereas climate change encompasses changes in all climate aspects, including sea level and precipitation. However, most individuals use the two terms interchangeably in practice.
- Here are the **key differences** between weather and climate:
  Weather refers to the current state of the atmosphere, including temperature, humidity, precipitation, wind, and cloud cover, over a short period (hours to days) in a specific location.
  Climate refers to the long-term patterns of temperature, precipitation, humidity, wind, and other weather variables in a region or across the globe over decades to centuries.
- **Weather** is the day-to-day or short-term condition of the atmosphere, while climate refers to the long-term averages and trends of weather variables. Weather changes rapidly and can vary from hour to hour or day to day, while climate changes more slowly and over a longer period.

PRACTICE QUESTIONS:

1. How do clouds affect the Earth's energy balance?

   A. They reflect sunlight back into space
   B. They trap heat in the atmosphere
   C. They both reflect sunlight and trap heat in the atmosphere
   D. They have no effect on the Earth's energy balance

2. What is the primary source of black carbon emissions?
   A) Industrial processes
   B) Residential and commercial buildings
   C) Biomass burning
   D) Transportation

3. What is the primary source of human-caused sulfur dioxide emissions?

   A. Industrial processes
   B. Agriculture
   C. Combustion of fossil fuels
   D. Deforestation

4. What is the difference between a positive feedback and a negative feedback in the Earth's climate system?

   A. Positive feedback amplifies changes while negative feedback reduces changes
   B. Positive feedback reduces changes while negative feedback amplifies changes
   C. Positive feedback only occurs in the atmosphere while negative feedback only occurs in the ocean
   D. Positive feedback only occurs in the ocean while negative feedback only occurs in the atmosphere

5. What is the primary concern about the potential collapse of the Gulf Stream?

   A) Loss of biodiversity in the region
   B) Increased sea level rise
   C) Changes in regional weather patterns
   D) Changes in global precipitation patterns

6. What is a climate tipping point?

   A. A point at which the climate has reached a stable state
   B. A point at which small changes in climate can lead to large, irreversible changes in the climate system
   C. A point at which the climate will return to its pre-industrial state
   D. A point at which the climate will stop changing altogether

7. What is an example of maladaptation in the conreading of climate change adaptation?

   A. Building sea walls to protect against rising sea levels
   B. Planting drought-resistant crops in anticipation of increased drought
   C. Relocating populations to higher ground to avoid flooding
   D. Building a dam to regulate water flow in a river

8. How can adaptation measures lead to maladaptation?

A) By prioritizing short-term solutions over long-term sustainability.
B) By focusing on local rather than global solutions.
C) By ignoring the potential negative side-effects of adaptation measures.
D) By not involving the community in the planning process.

9. What is a common challenge facing the deployment of geothermal energy technology?

A) High cost
B) Limited geographic availability
C) Lack of government support
D) Intermittency

10. What is the globally agreed limit of total CO2 emissions to stay below the 1.5°C target according to the Paris Agreement?
A. 2000 GtCO2
B. 1200 GtCO2
C. 1300 GtCO2
D. 1500 GtCO2

CHAPTER 2

Sustainability

Sustainability is the ability of humanity to meet its current needs while avoiding overburdening the environment and compromising the ability of future generations to meet their own needs. It involves environmental, social, and economic concerns, with the environment and its resources given equal footing with social and justice concerns and economic outcomes.

Environmental sustainability means preserving ecological integrity, biodiversity, and the balance of natural systems while consuming natural resources at a rate less than their replenishment.

Social sustainability involves providing basic necessities and human rights to all people and ensuring that they have sufficient resources to maintain health and security.

Economic sustainability refers to economic systems that are accessible to everyone and generate prosperity globally.

The concept of sustainability dates back to the 18th and 19th centuries, but it has been widely applied in public policy and corporate arenas since the 1970s and 1980s.

The Brundtland Commission report in **1987 defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs,** which became the most widely accepted definition of sustainability.

Today, sustainability is an important guiding principle for governments, international organizations, individuals, corporations, and financial institutions. Governments and international organizations advocate for sustainability, and international sustainability goals are established through the United Nations.

Many corporations have sustainability policies and strategies, adhere to ESG norms, and make commitments to align their business models with Paris Agreement-compliant emissions reduction goals. Investors and financial institutions practice sustainability through their ESG policies, sustainable finance product offerings, and commitments to align with sustainability goals. Consumers are also increasingly considering sustainability in their consumption choices.

ESG, Sustainability, and Climate Risk

The concept of sustainability can often lead to confusion and overlap, but it refers to actions that do not deplete or exploit resources, whether natural or human, in order to support continued economic activity into the future.

Sustainability encompasses actions taken by **individuals, corporations, financial institutions, and governments,** and involves both social and environmental awareness in order to ensure that economic activity does not harm society or the broader environment.

Social sustainability encompasses a range of practices from respecting human rights and ensuring worker protection to fair employment practices and promoting gender equality, **while environmental sustainability** includes addressing climate change, striving for clean air and water, protecting oceans, conserving habitats and nature, and preserving biodiversity.

ESG, that stands for environmental, social, and governance, began in the **financial industry** and serves as a set of standards by responsible investors **to evaluate companies on their ESG performance**.

Environmental criteria consider a company's relationship with climate change or nature, social metrics examine how a company treats its employees and manages relationships with suppliers and communities, and governance deals with a company's leadership, board composition, executive compensation, risk management, and other internal procedures.

ESG information is often disclosed by companies and collected by data firms or investors and is used for **screening companies for inclusion in ESG investment** funds or insight into banks', insurers', and investors' firm-level ESG policies.

Climate change is not exclusively an ESG issue, and **governments and corporations set policies and goals to reduce emissions and adapt to climate change, which is considered part of sustainable development** but not necessarily ESG. Overall, sustainability is a broad category that involves various stakeholders and spheres, including environmental, social, and governance considerations.

Sustainable Policies

2030 Agenda

The United Nations (UN) has a strong interest in promoting sustainable development, which can be traced back to the Brundtland report. To this end, the UN established several frameworks, including Agenda 21, which was adopted by 178 countries in 1992. **The Earth Summit in Rio de Janeiro**, where Agenda 21 was introduced, was facilitated by the **United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC** has been a major convening body for global climate decisions and has played a crucial role in coordinating communication between **the Intergovernmental Panel on Climate Change (IPCC)** and governments. **All major global climate policy agreements have occurred under the UNFCCC, including the 1997 Kyoto Protocol and the 2015 Paris Agreement.**

In 2000, the UN adopted eight **Millennium Development Goals (MDGs) to be achieved by 2015**. The goals included **eradicating extreme poverty, achieving universal primary education, reducing child mortality, improving maternal health, and ensuring environmental sustainability**. While the MDGs were helpful in generating discussions with governments and civil society, they ultimately fell short of their targets, with the flagship goal of eradicating poverty not being achieved. Furthermore, the **MDGs did not involve or engage private-sector stakeholders** such as corporations or financial institutions. As a result, **the UN** developed and launched **the 2030 Agenda for Sustainable Development in 2015**. This Agenda, which builds on the MDGs, centers on "people, planet, prosperity, and peace." Despite being similar in nature to the MDGs, the Agenda and

its Sustainable Development Goals have proven to be more impactful and influential, involving not just governments and civil society, but also private-sector stakeholders.

Sustainable Development Goals (SDGs)

The 2030 Agenda for Sustainable Development was launched in 2015 and consists of 17 Sustainable Development Goals (SDGs) which cover a much broader range of policies and areas than the previous Millennium Development Goals (MDGs). The SDGs are subdivided into 169 targets to provide specificity for better tracking and focus. The goals encompass a wide range of topics, including **environmental, economic, and social goals**.

Environmental goals include climate action and protection of life on land and in water, while **social goals** include good health, quality education, and gender equality.

Economic goals include good jobs, innovation, infrastructure, and responsible consumption.

The broad scope of the SDGs has allowed a wide range of stakeholders to find strong agreement and the detailed targets help to concretize implementation. Many private sector stakeholders have started to enumerate which SDGs their activities align with, and synergistic actions for tackling multiple goals are being taken, such as nature-based solutions for climate change mitigation.

Sustainable Development Goals (SDGs)

Goals	Objective	Description
Goal -1	No Poverty	By 2030, eradicate extreme poverty for all people everywhere.
Goal -2	Zero Hunger	End hunger, achieve food security and improved nutrition by 2030.
Goal -3	Good Health and Well-being	Ensure healthy lives and promote well-being for all at all ages by 2030.
Goal -4	Quality Education	Ensure that all girls and boys complete free, equitable and quality primary and secondary education by 2030.
Goal -5	Gender Equality	To achieve gender equality and empower all women and girls.
Goal -6	Clean Water and Sanitation	Ensure availability and sustainable management of water and sanitation for all by 2030.
Goal -7	Affordable and Clean Energy	Ensure access to affordable, reliable, sustainable and modern energy for all by 2030.
Goal -8	Decent Work and Economic Growth	Promote sustained, inclusive and sustainable economic growth.
Goal -9	Industry, Innovation and Infrastructure	Build resilient infrastructure, promote inclusive and

		sustainable industrialization and foster innovation by 2030.
Goal -10	Reduced Inequality	Reduce inequality within and among countries by 2030.
Goal -11	Sustainable Cities and Communities	Make cities and human settlements inclusive, safe, resilient and sustainable.
Goal -12	Responsible Consumption and Production	Ensure sustainable consumption and production patterns.
Goal -13	Climate Action	Take urgent action to combat climate change and its impacts.
Goal -14	Life Below Water	Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
Goal -15	Life on Land	Protect, restore and promote sustainable use of terrestrial ecosystems, combat desertification and halt biodiversity loss.
Goal -16	Peace and Justice Strong Institutions	Promote peaceful and inclusive societies for sustainable development; provide access to justice for all.
Goal -17	Partnerships to achieve the Goal	Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Source: United Nations Sustainable Development Goals

Ecosystem Services & Natural Capital

Ecosystem Services			
Supporting	**Provisioning**	**Regulating**	**Cultural**
Habitat	Freshwater	Flood regulation	Recreational
Nutrient cycling	Timber	Erosion control	Spiritual
Soil formation	Food	Water purification	Educational

The existence of all services is reliant on **supporting services** like genetic diversity and species habitat. Services that create resources such as food and freshwater can be traded in markets, these are called **provisioning services**. In contrast, **regulating services** like wetlands that clean polluted water or mangrove forests that mitigate hurricanes are less concrete and harder to measure. The third type of ecosystem service is **cultural services**, which are non-material benefits and enjoyment that people derive from ecosystems.

The private and public sector are increasingly recognizing the importance of ecosystems and the services they provide.

The Millennium Ecosystem Assessment (MA) found that the majority of the world's ecosystem services are declining, including supporting services that enable the existence of all other services,

provisioning services that generate resources for society, regulating services that are less tangible and harder to quantify, and cultural services that provide non-material benefits to humans.

Businesses, communities, and governments rely on ecosystem services for their profits, health, safety, and stability. Understanding the dependencies and effects of ecosystem services can inform business decisions and policy options.

The Natural Capital Protocol and the World Resources Institute Ecosystem Services Review offer methodologies to track organizational effects and dependencies on natural capital and ecosystem services, while the European Economic Area is developing an ecosystem accounting framework to measure the state of ecosystems across European nations.

Sustainability at Companies and Financial Institutions

The idea of combining business with social and environmental responsibility has existed for some time, with historical examples including Robert Owen's New Lanark Mills in Scotland and John Lewis & Partners, a British department store that has been an employee-owned mutual organization since its founding in 1920.

However, until recently, the prevailing view has been that businesses should **solely focus on maximizing profits, while social and environmental outcomes were seen as the responsibility of governments and other stakeholders.** This thinking changed in the 1980s and 1990s with the development of the **"triple bottom line"** concept, which placed **environmental and social impact on** equal footing with **financial performance**.

This led to the emergence of **corporate social responsibility (CSR), where companies acknowledged** their broader **obligations to society**. This idea gained significant attention in the 1990s, with many large multinational corporations launching CSR initiatives and issuing standalone sustainability reports. Investors also started showing interest in the sustainability of the companies they invested in, with responsible investment becoming more popular. The idea of **shareholder pressure for "good" emerged in the early 2000s, which was known as "engagement" and involved investors pressuring companies to act responsibly.**

The Sustainable Development Goals (SDGs) are now being used as a **benchmark by companies and investors to measure outcomes**. Although the **SDGs focus on non-financial outcomes** for **society, the environment, and the economy**, **many of them have material financial impacts on particular companies or industries.** As a result, individual companies are including references to the SDGs in their sustainability reporting and consultancies offer advice on how to integrate SDGs into their operations operations. Data firms also provide information on SDGs.

Financial institutions now analyze corporate performance through the lens of SDG alignment, and it has become a tool for screening companies and analyzing entire investment portfolios. MSCI offers an SDG Alignment Tool that measures a company's contribution to the UN SDGs. The SDG alignment allows for an easy way to present outcomes and priorities to investors in a cross-comparable manner between financial firms. **Shell (Anglo-Dutch oil & gas firm Royal Dutch Shell)**, for example, has been taking climate action on multiple fronts, including reducing its carbon emissions and supporting **the Paris Agreement's goals**.

Greenwashing

The practice of **Corporate Social Responsibility (CSR)** can lead to **greenwashing**, which refers to the deceptive use of environmentally-friendly claims for commercial gain.

Greenwashing can occur in two main ways:

- decoupling - Decoupling refers to situations where companies make claims about their sustainability efforts without actually making any meaningful changes in their practices. This can include joining voluntary sustainability initiatives for the sake of association, making false or empty promises, and outright lying.
- attention deflection. Attention deflection is when companies hide unsustainable practices or make selective and inaccurate disclosures to stakeholders. This can also involve vague or irrelevant statements, misleading texts or imagery, and incomplete comparisons with other products or services. At its worst, companies can even falsify information to gain accreditations.

Life cycle assessments (LCA)

Companies use **life cycle assessments (LCA)** to support their green marketing claims by examining every stage of a product's life cycle, including its environmental impacts from extraction of inputs to disposal.

LCA is a four-phase process as per ISO 14040, which includes **goal and scope definition, inventory analysis, impact assessment, and interpretation.**

There are four phases of an LCA, as laid out in ISO 14040:

1. Goal and scope definition—determine why an LCA is necessary and to whom the results are relevant. Identify the product and associated functions; define the product's system boundary by identifying the pro-cesses that contribute most to the product's environ-mental impact.

2. Inventory analysis—gather data on the inputs, outputs, and energy use of the product.
3. Impact assessment—characterize and categorize prod-uct impacts.
4. Interpretation—evaluate completeness of the LCA; develop conclusions and recommendations.

Besides supporting green marketing claims, LCAs help companies assess their **water, land, and energy use, carbon footprint, identify efficiency improvements, and make better supply chain purchase decisions.** LCAs are typically conducted for a few key products, but software systems are available to facilitate the process.

However, **LCAs mainly focus on environmental impacts and do not consider social or governance issues.** Therefore, it is crucial to consider other ESG issues when developing recommendations based on LCAs. LCAs are an essential building **block in creating a circular economy, which promotes economic growth without consuming finite resources, leading to reduced waste and pollution.** The data from LCAs also helps to monitor progress in achieving circular economies, which can contribute to advancing the SDG 12: Ensure sustainable consumption and production patterns.

Private-sector sustainability frameworks and coalitions have played a significant role in developing best practices on sustainability issues.

The World Business Council for Sustainable Development (WBCSD) was established after the UN Rio Summit in 1992 to conduct research on corporate social responsibility and share best practices on sustainability among its members.

The Principles for Responsible Investment (PRI) group was launched in 2006 and has played a similar role to the WBCSD for investors.

The PRI requires investors to commit to several principles, including

1. incorporating ESG issues in investments and decisions,
2. being active owners,
3. seeking disclosure on ESG issues from investee firms,
4. promoting acceptance and implementation of the principles,
5. collaborating to implement the principles,
6. reporting activities and progress toward implementing the principles.

Early coalitions like the PRI paved the way for later issue-specific groups such as the Alliance to End Plastic Waste, commodity-specific organizations like the Roundtable for Sustainable Palm Oil (RSPO), and climate groupings like Climate Action 100+. These coalitions have contributed to advancing sustainable development and promoting responsible business practices.

The Sustainability Accounting Standards Board (SASB) was established in 2011 to provide standardized sustainability metrics for cross-comparison. It is a **non-profit organization** that **aims to encourage companies to disclose financially significant sustainability information to investors**. The framework focuses on five dimensions of sustainability, including

1. **social capital,**
2. **human capital,**
3. **governance,**
4. **business model, and**
5. **environment.**

SASB has identified key issues relevant to each of the 77 industries it covers. Another similar initiative is the **Global Reporting Initiative (GRI),** which **provides global standards for sustainability reporting.** Climate risk is one of the most significant material sustainability risks, and various frameworks have been developed to address it. The Partnership for Carbon Accounting Financials **and the Taskforce on Climate-Related Financial Disclosures** are among the initiatives aimed at helping companies disclose climate risks.

BULLET POINTS:

- **Sustainability** means balancing economic needs with environmental protection and social responsibility.
- **Sustainable development** was the first application of the concept, focused on country-level development that doesn't harm nature or society. But now sustainability applies to individuals, corporations, governments, and financial institutions.

- **ESG** is a part of sustainability that measures firms' environmental, social, and governance performance and is commonly used by financial counterparties. Climate action is a vital aspect of the environmental agenda.
- The **UN's 2030 Agenda**, specifically the **Sustainable Development Goals**, is an essential reference point for policymakers and businesses.
- **Corporate sustainability** has shifted from being motivated by corporate social responsibility and branding to considering financial materiality.
- Coalitions and frameworks are significant in spreading sustainability practices within the private sector.

PRACTICE QUESTIONS

1. What is the root of the concept of sustainability as applied to today's public policy and corporate arenas?

   A. The Limits to Growth
   B. The Brundtland Commission
   C. The first major United Nations meeting on environmental issues
   D. The industrial revolution

2. What is the main use of ESG scores and metrics by financial firms?

   A) To screen companies for inclusion in ESG investment funds.
   B) To evaluate a company's performance for its shareholders and other stakeholders.
   C) To evaluate sovereign bond portfolios.
   D) To integrate ESG policies into lending, underwriting, and investment practices.

3. What is ESG?

   A. An abbreviation used by the financial industry.
   B. An abbreviation used by governments to refer to their policy actions.
   C. A set of standards used by responsible investors to gauge companies.
   D. A type of investment fund.

4. What are the 17 Sustainable Development Goals (SDGs) about?

   A. Environmental and economic goals
   B. Social and economic goals
   C. Environmental, economic and social goals
   D. Environmental and social security goals

5. What is the term “corporate social responsibility” (CSR) about?

   A) Companies having a broader obligation to society
   B) Achieving only financial performance
   C) The exclusion from investments
   D) The notion of using shareholder pressure for good

6. What is the purpose of the Principles for Responsible Investment (PRI) group?

   A. To conduct research on corporate social responsibility and share best practices on sustainability
   B. To guide and set standards for sustainability reporting
   C. To promote the incorporation of ESG in investment decisions and increase disclosure on ESG issues
   D. To provide holistic recommendations for disclosing climate risks

7. What is the primary goal of ESG evaluations?

   A) To maximize profits for companies and organizations
   B) To assess an organization's impact on the environment and society
   C) To increase economic growth

D) To improve social conditions

8. Which of the following initiatives aims to promote sustainable procurement practices?

A. Global Sustainable Procurement Alliance
B. Sustainable Procurement Network
C. Sustainable Supply Chain Alliance
D. Responsible Procurement Network

9. What is the significance of considering the entire life-cycle of a product in the Life-cycle Assessment (LCA) process?

A) It provides a comprehensive evaluation of the environmental impact of a product
B) It provides a comprehensive evaluation of the financial performance of a product
C) It provides a comprehensive evaluation of the market demand for a product
D) It provides a comprehensive evaluation of the product quality

10. What is the definition of "greenwashing"?
A. The act of making false or misleading claims about the environmental benefits of a product or service
B. The act of promoting environmentally friendly practices in a genuine manner
C. The act of using green marketing strategies to increase sales
D. The act of using environmentally friendly materials in the production process

CHAPTER 3

Climate Change Risk

The concept of **climate risk** is a subset of the broader discussions around climate change and refers to **financial risks** associated with the phenomenon.

Climate change is scientifically proven to be caused by **human-induced emissions of greenhouse gases**, and governments are increasingly setting goals to achieve net-zero emissions by 2050. However, there are still debates over the most appropriate means to address and adapt to the physical impacts of climate change. The notion of climate risk comes largely from financial regulators and private-sector institutions, such as **the Taskforce on Climate-related Financial Disclosures (TCFD**), which was formed in 2015 and is composed mainly of private-sector representatives from financial and non-financial corporations. The TCFD has been particularly influential in developing a risk-based approach to climate change. **Climate risks can affect financial balance sheets** and **lead to losses through standard channels such as diminished asset valuations or increased loan defaults.** The TCFD's outputs, such as its final report from 2017, have provided a framework for understanding climate risks and categorizing subtypes of transition risk.

Types of Risks

Climate risk is best understood by examining the ways in which climate change affects assets, how they transmit into the real and financial economies, and how different sectors are differentially affected.

The concept of climate risk is divided into two main categories:

1. **physical risk**
2. **transition risk**.

Physical risks arise from the physical climate impacts caused by **changing weather patterns**, while transition risks arise from the necessary economic transformation to reduce and eventually eliminate net greenhouse gas emissions, to reach the goal of net-zero emissions.

Physical risks are divided into:

1. **acute**
2. **chronic hazards.**

Acute hazards include weather-related events, such as floods, hurricanes, and wildfires, while **chronic hazards** include long-term trends, such as rising temperatures and sea levels.

On the other hand**, transition risks** result from factors such as **government policies to reduce emissions, technological changes, and consumer demand for sustainable products**. However, in the face of these hazards and factors, different assets and companies have varying levels of **exposure and vulnerability.**

Exposure refers to the assets or firms that are in a vulnerable setting, such as a factory in a low-lying coastal area. **Vulnerability,** on the other hand, refers to the predisposition of assets or firms to suffer from their exposure to hazards. **Vulnerability** can also refer to a lack of preparation for issues such as climate change mitigation and adaptation planning, or to a lack of financial resilience, such as through insurance-based mechanisms.

Climate Risk	Hazards/Drivers	Exposure	Vulnerability
Physical Risks	• Acute weather hazards (floods, cyclones, droughts) • Chronic weather hazards (sea level rise, heat, water stress)	**Facility level:** Anything in a hazard zone (infrastructure, residential property, commercial facilities) **Corporate level:** Firms with facilities/supply chains in hazard areas	**Facility level:** Extent of adaptive infrastructure (e.g., flood pumps, fire breaks) **Corporate level:** Viability of contingency plans; access to insurance
Transition Risks	• Policy changes (carbon tax, coal shutdowns) • Technological changes (cheaper renewables) • Consumer pressure	Facility level: High-emissions assets (fossil fuel power plants, steel plants, ICE vehicles) **Corporate level:** Firms with business operations dependent on emissions	**Facility-level:** Extent of ability to decarbonize (e.g., biomass or hydrogen conversion) **Corporate-level**: Viability/robustness of transition plan

Source: SCR Certificate (2023)

Stranded asset

The concept of **stranded assets** has become increasingly important in the realm of climate risk and sustainability. Stranded assets refer to assets that have suffered a reduction in value or have become liabilities due to unanticipated or premature write-downs or devaluations.

The concept of stranded assets has been applied to climate risk, specifically with regards to **"unburnable carbon,"** known oil or coal reserves that cannot be fully exploited if the agreed goals of limiting warming to 2°C or 1.5°C are to be met, resulting in coal mines or oilfields becoming "stranded assets."

Stranded assets are not limited to transition risks, as physical risks can also create stranded assets, such as a beverage factory being stranded by droughts limiting access to fresh water.

Physical risk stranding can occur across nearly all sectors, but is more likely to be concentrated geographically, such as sea-level rise and coastal flooding stranding facilities in vulnerable

areas. Stranded assets can also refer to assets stranded by non-climate environmental risks, such as habitat destruction or tighter restrictions on local air pollution.

Physical Risks

The physical impacts of **climate change** are already being experienced, and they are linked to specific **events that can be attributed to climate change through attribution science**. The future physical impacts of climate change will depend on future emissions, but even if the most ambitious Paris goals are met, the effects will still be severe. **Hazards** resulting from physical risks are subdivided into **acute and chronic hazards that interact with exposure and vulnerability**.

Chronic Climate Hazards	Acute Climate Hazards
• **Average temperature rise** • **Sea level rise** • **Changing precipitation patterns**	Increased incidence of the following: • Storms and hurricanes • Droughts • Heatwaves • Precipitation extremes and floods • Wildfires

Source: SCR Certificate (2023)

Understanding the physical impacts of climate change is crucial in assessing climate risk.

Acute hazards refer to weather-related or weather-exacerbated events such as floods, hurricanes, and wildfires. **Chronic hazards**, on the other hand, are gradual, long-term trends like rising temperatures and sea levels.

While there is strong scientific evidence that all physical hazards are linked to **climate change, predicting the magnitude, frequency, and location of specific hazards** can be challenging, particularly for **precipitation patterns**.

Climate models provide varying degrees of accuracy for different hazards and timescales. Local conditions also play a crucial role in the interaction of climate events, such as flooding and wildfires, which makes it difficult to accurately predict their location.

Natural catastrophe data from the past several decades **shows an increased incidence of acute hazards, which is expected to continue**.

Attribution science is a new branch of climate science that is able to show how specific events are caused by climate change. For example, research has shown that climate change made the Australian wildfires of 2019-2020 at least 30% more likely and that the huge Thai floods of 2011 would likely not have occurred without climate change. The Siberian heatwave of 2020, which saw temperatures reach a record 38°C in Verkhoyansk, far above the Arctic Circle, would have been almost impossible without human-caused climate change.

Direct Physical Risks

Direct physical risks related to climate change are not easy to understand in terms of their impact on specific assets or companies. **Climate models** vary in their ability to **predict the magnitude,**

frequency, and location of specific hazards, and regional or local estimates are less precise than global estimates. **Physical risks arise only when there is exposure and vulnerability**, and it can be difficult to obtain precise data on these hazards.

Obtaining accurate data on climate hazards and their potential impacts is a challenging task. While some data is freely available from academic institutions and NGOs, more precise data on hazards such as flooding may require purchasing from specialist consultancies. Additionally, the resolution of climate data can greatly impact its usefulness, with some hazards requiring hyper-local data to accurately assess risks. **Downscaled climate models** may also **lack robustness and accuracy** over shorter time frames, further complicating the task of obtaining precise data on climate risks.

Mapping exposures can be done with precise location data, but vulnerability refers to facility-level preparedness, for which there is still very little visibility or data.

Legacy assets and supply chain interdependencies can make it difficult for large firms to obtain detailed information on their own physical risks, and other stakeholders such as banks, institutional investors, auditors, or credit rating agencies may have limited data access. **Climate engineering consultancies** can help evaluate the present state of adaptive infrastructure, but the availability and granularity of data on physical risks remain a challenge.

Vulnerability, however, is an area where there is still very little visibility or data because it ultimately refers to facility-level preparedness.

Indirect Climate Hazards

The physical risks of climate change not only affect assets and companies through direct exposure to hazards but also have **indirect effects**, such as **supply chain risk, liability risk, and systemic risk.**

Supply chain risk is particularly relevant since all firms rely to some extent on suppliers, and physical risks can disrupt the production process.

Liability risk can occur when companies are held legally liable for not adequately preparing for physical risks.

Indirect physical risks that are systemic in their propagation effects and multifaceted nature can be challenging to quantify, such as the effects of heat stress on worker productivity. For instance, the International Labor Organization estimates that by 2030, the global temperature rise is expected to cause the equivalent of 80 million full-time job losses, resulting in a net loss of over USD 2.1 trillion in 35 years of climate change alone.

Opportunities, Resilience, and Adaption of Physical Risks

The management of physical climate risk for **private sector companies presents more downside than upside,** as it can result in **huge losses and business interruptions**. **To mitigate financial losses**, companies **rely on insurance**, which is crucial in dealing with physical climate risks.

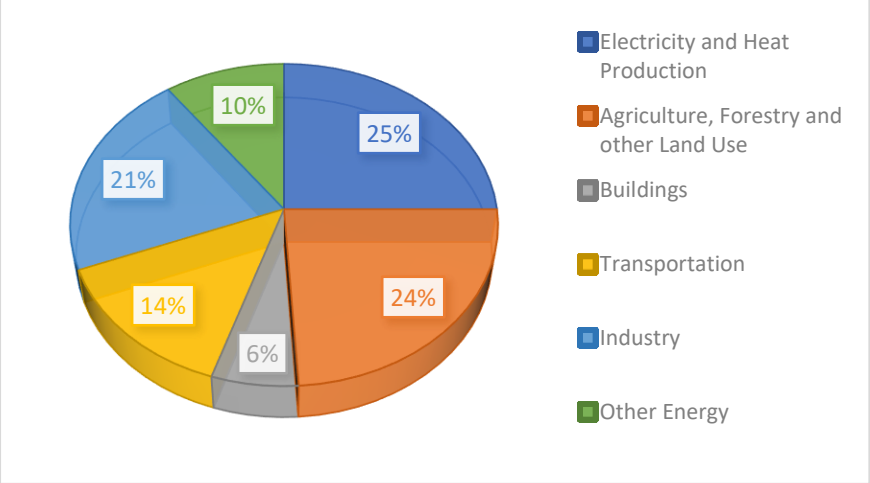
However, the willingness of insurers to provide coverage in areas with severe exposure to climate risks, such as fire-prone areas in California and Australia, is becoming limited. This may result in a scenario where firms and financial counterparties stop investing in areas that are most vulnerable to physical climate risks, leaving only homeowners unable to sell their properties. Nonetheless, there is a

chance that the corporate sector can find **opportunities in dealing with physical risk by partnering with governments, insurers, and communities to build adaptive infrastructure such as flood walls that can protect both facilities and surrounding communities.** By finding solutions that allow for both burden- and profit-sharing, companies can be rewarded for staying in certain areas, while insurers can work proactively to encourage the **uptake of adaptive measures and share expertise on resilience.**

Transition Risks

Current **business-as-usual** scenarios predict that CO2 emissions **will continue to rise to around 60-120 Gt per year,** while keeping global warming below 2°C requires a sustained and rapid decrease in emissions across all sectors of the economy. Even more challenging is the goal of limiting warming to 1.5°C, which requires large-scale removal of greenhouse gases from the atmosphere through techniques such as **direct air capture or bioenergy with carbon capture and storage**.

From decades of consistently rising global emissions, the whole global economy, especially electricity and heat production (25% of emissions), industries (21%), transportation systems (14%), and agricultural practices (24%) must be thoroughly over-hauled to reach net-zero emissions by 2050.



Source: IPCC AR5 Climate Change 2014: Mitigation of Climate Change.

Transition risks arise from the uncertainty and challenges associated with this transition to a low-carbon economy. While policies such as **a carbon tax or cap-and-trade schemes** are seen as the optimal solution, their implementation has been limited due to political realities.

However, **the transition to a low-carbon economy also presents numerous economic and investment opportunities, including the development of sustainable products and services, renewable energy, and innovative technologies.**

TCFD-outlined best practices in describing transition risk drivers as including **policy and legal risks** (encompassing factors ranging from mandatory shutdowns to legal liability); **technology risks** (e.g., cheaper renewables making fossil fuel–based power generation less economical by comparison); **reputational risks** (e.g., from bottom-up consumer pressures for sustainable products); and other risks, such as market risks.

Policy and Legal Risks

Various **policy and legal risks** can contribute to climate transition risk. Traditionally, **policy solutions to reduce emissions have focused on implementing either carbon taxes or cap-and-trade schemes.** However, other policies, such as **energy efficiency standards or government-mandated closures, can also create transition risks**. These risks can range from **fines and penalties to litigation and changes in company valuation.**

Litigation can arise from activist and advocacy organizations filing suits against carbon-intensive projects, claiming that they breach existing environmental rules or commitments. For example, ClientEarth, a climate litigation NGO, filed a suit against Enea, a Polish utility, alleging that Enea failed to consider climate-transition risks when building a large coal-fired power plant.

Another form of legal risk involves **holding companies proportionally liable for their contribution to the physical impacts of climate change through their emissions.** In the Lliuya v RWE case, a Peruvian farmer alleged that RWE, a German utility, partially caused the melting of glaciers around a lake due to its historic emissions, increasing flood risk. This argument relies on the idea that companies can be held proportionally liable based on their contribution to all human emissions. If successful, this type of litigation could become a significant source of legal liability risk for firms.

Technology Risks

Technological advancements, while often seen as beneficial, can also **create transition risks for companies relying on outdated technology that becomes less economical or obsolete**. This is particularly true for **renewable energy technology**, which has seen significant price drops in recent decades. **Wind turbines and solar panels are now cost-competitive** with traditional power generation technologies that rely on fossil fuels. For example, solar modules have dropped in price from over $100 per watt in 1976 to less than $0.50 per watt in 2019. Similarly, **lithium-ion batteries are becoming increasingly cheaper**, which has implications not only for utility-scale energy storage but also for the transportation sector.

Reputational Risks and Consumer Pressure

Reputational risks and **consumer pressure** can also contribute to transition risks for companies. **Reputational risks** occur when a firm's brand and image are tarnished by its association with industries that are seen as unsavory. Similarly, the concept of "**social license to operate**" means that firms must meet a minimum level of acceptability to avoid being viewed as immoral or unconscionable by wider society. **Sectors such as tobacco or certain weapon manufacturers** have come close to going out of business due to reputational risks, impacting their share prices and access to capital markets. **High-emission, climate-unfriendly industries, such as coal and tar sands**, are also becoming viewed as broadly noxious, with many firms excluding lending or investing in them. **Consumer pressure** can be a significant driver of change, providing opportunities for flexible firms and creating transition risks for inflexible or slow-to-respond firms. In consumer products sectors, firms that increase the selection and availability of sustainable products will be more successful than those that are slower to adapt. The increasing recognition of the high climate footprint of meat and dairy products has driven demand for plant-based meat and dairy alternatives. Consumer influence also exists in other sectors, such as technology and commodities.

Market and Other Transition Risks

Market risks are another significant source of transition risks, encompassing a broad range of potential supply, demand, and pricing effects. **Shifting demands** from high-emissions products to low-carbon alternatives is one example of market transition risks. As industries and equipment transition to cleaner fuels or become electrified, demand for coal and oil and gas will fall, potentially leading to market disruptions for sectors such as coal mining and bulk coal shipping. Additionally, shifts and spikes in demand for low-carbon commodities, such as lithium and copper, used widely in electric vehicles and other electric equipment, may also cause market disruptions.

Shareholder perceptions or pressures in public markets can also create market transition risks. Historically, a large portion of the value ascribed to oil and gas firms has been due to their proven reserves, but as a portion of these reserves may become stranded, market capitalizations of oil majors have fallen. Oil majors have had to write off assets, such as when BP cut the value of its assets by $17.5 billion in June 2020, and Royal Dutch Shell by $22 billion. Therefore, companies must be aware of market risks and adapt to changing market demands to avoid transition risks.

Not only tangible assets, but intangible assets such as **intellectual property, social networks, and reputation can also become stranded due to the same drivers that result in tangible assets stranding.** The intangible assets, particularly in advanced economies, are becoming an ever-larger share of total enterprise value.

The idea of a **"just transition"** is gaining interest and concern, where those who are likely to suffer the most from asset stranding are supported through retraining provided by companies and governments. This could create political economy frictions within and across countries. The faster the pace of decarbonization, the higher the chance of stranded assets in different sectors and the larger the likely economic, social, and political consequences that might need to be managed. This is particularly relevant to developing countries who have a right to development and access to affordable energy while facing the consequences of global warming and dwindling resources. A just transition reconciles the sustainable use of natural resources with a commitment to sufficiency by reallocating resources and compensating those affected by climate change and related policies. **Job losses** are caused by a lack of social policies and anticipation of alternative mitigation measures, and providing adequate support for sectors losing out in a low-carbon future and generating new employment opportunities in low-carbon sectors is critical to ensuring a just transition.

Example: Case Study «Physical and Transition Risks in Real Estate»

Real estate is particularly vulnerable to physical climate risk, such as wildfire and flood risks. Flood and/or sea level rise is an acute hazard in the real estate sector, particularly for properties located near coastlines or rivers. Empirical evidence shows that US properties exposed to sea level rise sell for less than unexposed properties (less 7 %), indicating the transmission of coastal flooding risk into the property market and wider financial system. Transition risks in the real estate sector mainly arise from the energy use of buildings, particularly heating and electricity use from fossil fuel-based sources. New building codes that require higher energy-efficiency standards and renewable sources of energy can cause transition risk for property owners and lenders.

The UK's Minimum Energy Efficient Standard (MEES) rule could lead to transition risk for lenders if landlords' credit positions deteriorate due to lost rental income or the market value of properties falling. The energy-efficiency rating of a property is a predictor of credit risk on residential mortgages, according to the Bank of England.

Case Study: Electricity Generation

The electric utilities sector is particularly affected by transition risk, with coal-fired power plants being a significant focus of attention due to their high emissions. Transition policy risk can lead to stranded assets if coal plants close before their operational lifetimes. Technology transition risk in the form of cost competition from renewable technologies is also affecting coal power generation. The electricity generation sector can also be significantly affected by physical climate risk, such as wildfires in California in 2018 caused by poorly maintained equipment from Pacific Gas & Electric (PG&E) and a cold snap in Texas in 2021 which led to rolling blackouts and several deaths. Climate change-induced increases in summer temperatures and intensification of droughts have been a significant contributor to wildfires in the western US. The lack of preparedness in Texas serves to highlight the need to prepare for more extremes going forward.

BULLET POINTS:

- Climate risk can result from physical effects caused by climate change or by efforts to reduce greenhouse gas emissions - known as **transition risk**.
- Climate risk occurs due to an interaction of hazards or driving factors with **exposure and vulnerability.**
- Assets that are environmentally unsustainable or climate-affected can become **stranded assets** due to premature write-offs **caused by physical or transition risk**.
- While global average temperatures are expected to increase, the accuracy of estimates for other hazards, such as precipitation patterns, can vary.
- **Physical risks** can have direct and indirect effects, such as through supply chains, legal liability, or systemic and second-order effects.
- The economic transformation needed to achieve climate change targets, which is a source of transition risk, is unprecedented in scale and speed.
- Transition risks can arise from policy changes, technological advancements, reputational and market risks.
- Climate risk impacts corporate and financial balance sheets, as well as consumer spending patterns, but the effects vary by sector.

PRACTICE QUESTIONS

1. What is climate risk in financial terms?

   A. Financial risks linked to natural disasters
   B. Financial risks linked to climate change
   C. Financial risks linked to environmental issues
   D. Financial risks linked to renewable energy

2. What are the two categories of climate risk?

   A. Physical risk and economic risk
   B. Physical risk and transition risk
   C. Acute and chronic hazards
   D. Carbon taxes and technological changes

3. What is an example of corporate level vulnerability to transition risk?

   A. Flood pumps
   B. Rising sea levels
   C. Lack of preparation for climate change mitigation
   D. Carbon taxes

4. What is the definition of stranded assets?

   A. Assets that have suffered devaluations or conversion to liabilities
   B. Assets that have not been used to their full potential
   C. Assets that have been impacted by environmental risks
   D. Assets that have been impacted by market trends

5. What is the focus of TCFD metrics and targets?

   A. Climate change mitigation strategies
   B. Climate-related risks and opportunities
   C. Environmental sustainability
   D. Board level decision making

6. What is required to map exposures to climate hazards?

   A) Climate data
   B) Precise location data
   C) Both A and B
   D) None of the above

7. Which of the following is a chronic climate hazard?
   A. Floods
   B. Hurricanes
   C. Rising average temperatures
   D. Rising sea levels

8. What information is needed to assess the vulnerability of physical assets to climate risks?

   A. Location data

B. Adaptive infrastructure information
C. Climate engineering evaluations
D. All of the above

9. What are the main sources of stranded assets in the conbook of climate risk?

A) Only transition risk.
B) Only physical risk.
C) Both transition risk and physical risk.
D) Neither transition risk nor physical risk.

10. What is necessary to ensure a just transition in a low-carbon future?

A. Providing support for sectors that are losing out
B. Generating new employment opportunities in high-carbon sectors
C. Failing to provide adequate support for those affected
D. Ignoring the needs of under consumers

CHAPTER 4

Sustainability And Climate Policy

The global community has attempted to agree on international climate policies since the 1990s, focusing on emissions reductions. **The United Nations Framework Convention on Climate Change (UNFCCC)** was established in **1992**, followed by **the Kyoto Protocol in 1997**, and **the Paris Agreement of 2015**. Understanding the reasons for the difficulty and slow progress in global climate policy requires knowledge of the background situation, open questions, and the different ways agreements have attempted to resolve them. Sustainability and climate-related issues have gained prominence in other areas, including private-sector practices, financial policy, and regulation.

One significant aspect of the background of international climate policy is **the scientific evidence** that **human greenhouse gas emissions are warming the planet's climate**. This consensus was reached in the 1970s and 1980s, leading to the formation of **the Intergovernmental Panel on Climate Change (IPCC) and the UNFCCC.**

Economists, such as **William Nordhaus**, developed **models to assess the costs and benefits of mitigating climate change through emissions reductions versus the physical impacts of climate change**. Climate scientists have tended to be more conservative, and recent evidence suggests that even lower levels of warming can lead to severe physical impacts and potentially catastrophic "tipping points."

Another open question concerns **the allocation of moral responsibility, particularly the relationship between a country's wealth, historical emissions, and the potential trade-off between emissions and economic development.** Countries that have increased their share of emissions in the past two decades, such as **China and India**, differ from those responsible for **cumulative emissions, such as the US, EU, Russia, and Japan,** and those **expected to drive future emissions unless they adopt green growth models, such as Saudi Arabia, Indonesia, and Brazil**.

Current vs. Cumulative Emissions: There is a contrast between the countries that are currently the largest emitters and those that have contributed the most to rising emissions. China has by far the largest current annual emissions, followed by India. However, Europe and North America have a far larger share of cumulative emissions because they started industrialization earlier than Asia.

Importance of Cumulative Emissions: Cumulative emissions matter more because they reflect the total stock of CO2 in the atmosphere, which affects changes in climate.

Cumulative CO2 Emissions by Country: The United States is responsible for a quarter of global cumulative emissions, and the former 28 countries of the European Union account for just over a fifth. North America and Asia both account for 29% of global emissions through 2017, while Europe accounts for a full third.

The inherent difficulties of collective action present another challenge to international climate policy. Global emissions and efforts to reduce them constitute a classic collective action problem, as countries face disincentives that discourage joint action in pursuit of a common goal. This tension is complicated by the fact that reducing greenhouse gas emissions incurs short-term costs but provides long-term benefits that may be realized by all countries. As a result, countries may be disinclined to implement painful emissions cuts and tempted to free-ride off the emissions cuts of others.

History of International Climate Agreements

The history of international climate summits dates back to 1979 with **the first World Climate Summit** organized by **the World Meteorological Organization (WMO).**
In 1992, the United Nations introduced the **United Nations Framework Convention on Climate Change (UNFCCC) at the Earth Summit in Rio de Janeiro**.

The first major international accord on emissions reductions was produced at the third conference of the parties **(COP3) in Kyoto in 1997**, where **high-income countries agreed to attain 5% emissions** reductions compared to 1990 levels by 2008–2012. However, **the Kyoto Protocol** is widely **viewed as a failure**, as it did not achieve even the modest emissions targets embedded within it due to issues such as developing countries not being subject to any kind of emissions reduction obligations. Expectations were high for the post-Kyoto space negotiations at COP15 in Copenhagen in 2009, but no agreement was made.

The Paris Agreement in 2015 built on the ideas introduced at Copenhagen and is based on commonly agreed aspirations to limit global temperature rise to below 2°C and to pursue efforts to limit the rise to 1.5°C, combined with national efforts by each party.

National plans, or Nationally Determined Contributions (NDCs), are submitted to the UNFCCC and evaluated periodically. The Paris Agreement also established a "ratchet" mechanism where countries are expected to tighten their NDCs every five years. The success of the Paris Agreement is attributed to its different structure and approach from Kyoto, as it makes use of the powerful tools of inclusion and peer pressure, and recognizes the contributions of various stakeholders, ranging from subnational actors to private-sector businesses and financial institutions.

Climate Policies

To achieve their **Nationally Determined Contributions (NDCs) for reducing greenhouse gas emissions,** countries must have **a domestic climate policy**.
These policies can either be **economy-wide, such as carbon pricing, or sector-specific, such as policies aimed at reducing emissions in power generation and transportation.**
Carbon pricing includes **carbon taxes and emissions-trading schemes**, which have their advantages and disadvantages.
Carbon taxes raise revenue for the government, but may be subject to frequent adjustments, which can negatively affect business investments.
Emissions-trading schemes, on the other hand, allow for flexibility and can create a market for emissions permits, but may cause volatile pricing and oversupply of permits.
In addition to carbon pricing, specific policies in power generation, such as R**enewable Portfolio Standards and Feed-in tariffs**, have had significant impacts on emissions reductions. **The transportation sector** has also implemented regulations, such as **fuel efficiency standards and electric vehicle purchase subsidies**, to reduce emissions. Many other policies in different sectors,

such as home energy-efficiency requirements and land use regulations, also contribute to emissions reduction.

Emissions Reductions Policies

Policy	Sector	Description
Carbon tax	Cross-sectoral	A tax per ton of CO2 emitted disincentivizes emissions and col-lects tax revenue that can be used for further climate measures.
Emissions-trading scheme	Cross-sectoral	An emissions-trading scheme reduces emissions but allows sec-tors to trade with each other, so emissions are reduced where it is easiest and cheapest to do so.
Renewable portfolio standard	Power generation	A requirement of a specific proportion of electricity generation coming from renewable sources
Automobile fuel effi-ciency requirements	Transport	A requirement that individual cars, or fleets, must satisfy a mini-mum standard of fuel efficiency to be legally allowed
Fuel tax	Transport, Heating	A fuel tax can lower the demand for fuel or be used to disincen-tivize the use of dirtier fuels
Building heating / energy-efficiency requirements	Buildings	Building requirements can be used to forbid the use of carbon-emitting heating technologies (e.g., natural gas furnaces, oil heat-ing) in new buildings in favor of renewable alternatives
Ban on burning peat bogs / wetlands	Agriculture and land use	Generally, peat bogs and wetlands are a huge store or carbon. Some peat bogs have historically been periodically burnt for land management purposes, but banning burning (as in the UK) will reduce emissions
Green / low-carbon public procurement	Transport, Buildings etc.	Governments can use their purchasing power to opt for green and sustainable alternatives (e.g., for public-sector buildings, public transport, etc.), helping to spur more general uptake and develop technologies

Source: SCR Certificate (2023)

Although a significant portion of **climate policy** is conducted **at the national level**, subnational efforts are becoming increasingly important in the fight against climate change. These efforts are often led by **states, regions, and cities**, and are sometimes driven by political systems that allow for more ambitious climate policies than those at the national level.
Some examples of **subnational climate policies** include **the Tokyo metropolitan area emissions-trading scheme in Japan, and the Regional Greenhouse Gas Initiative in the United States**, which covers large power plants across ten northeastern states.
Other subnational efforts, such as the C40 coalition of **cities,** function more as networks and advocacy groups. **America's Pledge**, launched in response to the United States' withdrawal from the Paris Agreement, is a prominent example of the increasing collaboration between public and private entities in subnational climate initiatives.
In aggregate, these subnational efforts are becoming more impactful, with one assessment finding that full implementation of non-state and subnational climate commitments could result in **emissions reductions of 3.8-5.5%** more by 2030 than national pledges alone in ten large, high-emissions economies.
The Corporate Accounting and Reporting Standard, established by the **GHG Protocol** over 20 years ago, has become the most widely used standard for corporate greenhouse gas (GHG) emissions accounting and reporting.
The **GHG Protocol** include the following:
• **The Project Protocol**—for quantifying the GHG emissions reduction benefits of climate change mitigation projects.
• **The Corporate Value Chain** (Scope 3) Standard—for companies to assess their entire value chain emissions impact and identify where to focus reduction activities.
• **The Product Standard**—used to understand the full life cycle emissions of a product and focus efforts on the greatest GHG emissions reduction opportunities.
• **The Policy and Action Standard**—a standardized approach for estimating the GHG effect of policies and actions.
• **The Mitigation Goal Standard**—guidance for designing national and subnational mitigation goals and a standardized approach for assessing and reporting progress toward goal achievement.

The Corporate Standard distinguishes between **direct and indirect emissions**, as well as between **Scope 1, 2, and 3 emissions**.
Direct emissions are from sources owned or controlled by the reporting company, while **indirect emissions** occur at sources owned or controlled by another company.
Companies have control over their **direct emissions** but **influence over their indirect emissions**.
Scope 3 emissions, which occur **in the value chain** of the reporting company, are the most vulnerable to potential climate transition risks, especially for companies facing climate risks that could result in stranded assets.
However, only 32% of corporate net-zero targets cover the entirety of Scope 3 emissions. The potential for **double counting** exists when examining emissions associated with a portfolio of companies. To address this, the **GHG Protocol recommends that Scope 3 emissions should not be aggregated.** However, due to significant **interest in** understanding the GHG emissions associated with **financial portfolios and loan books**, **Scope 3 emissions from portfolio companies are often aggregated to compare the carbon intensity of portfolios.** This poses a challenge for financial institutions and data providers who are grappling with double counting issues.

Climate Risk and Financial Policy

The International financial institutions (IFIs), such as multilateral development banks (MDBs) and **Development Financial Institutions (DFIs)**, were some of **the earliest organizations to create investment policies related to sustainability and climate risks**.

MDBs have a mandate to support **public-sector investment in physical and human capital projects** that encourage socioeconomic development, while **DFIs** also support the development of the **private sector.**

The IFIs were created with a **double bottom line mission**, which means that they **aim to be financially self-sufficient while supporting socioeconomic development, rather than solely maximizing profits.**

The **IFIs** have been writing detailed reports on climate risk for many years, and have launched initiatives such as the **"Climate awareness bond"** to promote climate-related investments.

In 2019, **the International Finance Corporation (IFC)** partnered with the private sector to develop the **Operating Principles for Impact Management (OPIM),** which assess **the impact of management systems on environmental and climate-related aspects**. **Private financial institutions** are now replicating parts of the multilateral and bilateral DFI model, with the launch of the J.P. Morgan Development Financial Institution in 2020, which aims to finance the UN Sustainable Development Goals in emerging economies.

The public policy relating to finance promotes the presence and activity of the private financial sector, with r**ecent incorporation of green elements** as climate change becomes a more prominent issue.

Various green finance **"hubs"** or **taskforces** have been set up globally, such as the **TCFD Consortium of Japan, Centre for Green Finance in Hong Kong, Green Finance Action Plan in Singapore, Green Finance Institute in the UK, and the Luxembourg Sustainable Finance Initiative. Some of these networks are transnational, such as the Financial Centres for Sustainability (FC4S) with 30 financial centers promoting sustainability.** The (Financial Centres for Sustainability) FC4S has a permanent secretariat providing research, guidance on best practices, and project development and support services to its members.

Green Taxonomy

Green taxonomies are emerging as a **public policy and regulatory response to climate change and environmental challenges.** Several jurisdictions, including ASEAN, Canada, China, the EU, Malaysia, and the UK, are creating lists of economic activities considered **"green."**

The EU Taxonomy is the furthest along and sets performance thresholds for economic activities to count as **"green." Green taxonomies inform policy, regulatory, and market decisions and are used to guide fiscal policy, determine green subsidies or incentives, and possibly determine tax or other incentives for investments in green companies and assets.**

Proponents argue that green taxonomies facilitate comparability, reduce the burden of determining if an investment is green, and tackle greenwashing.

However, **potential drawbacks** include **binary "green" assessments (***the assessment of "green" investments may have varying degrees of "greenness" depending on local and national contexts and the timing of the evaluation***), lobbying (***the development of a green taxonomy can be subject to lobbying and political influence, which may undermine its credibility***), asset bubbles (***a green taxonomy may also lead to artificially inflating the value of assets labeled as green, potentially*

creating financial instability)**, sub-optimal targeting (***incentives based on a green taxonomy may benefit not only investors in new green assets but also those who have already invested in profitable green assets*)**, and decreased quality (***green taxonomies may lead to decreased quality if institutions only focus on the label without properly evaluating the underlying economic activities and cash flows of the investment*)**.** There are nascent efforts underway to create brown or transition taxonomies, and creating a universal green taxonomy across multiple jurisdictions is likely a long way off.

Climate Risk and Financial Supervision

Central banks and financial regulators have integrated climate change into their supervision practices over the past five years, following the lead of the Bank of England.

The Network for Greening the Financial System (NGFS) was established as a platform for central banks and regulators to collaborate and share expertise on climate risk. Climate integration has been incorporated into both **microprudential (**the oversight of specific financial institutions (usually banks and insurers) for financial soundness**) and macroprudential supervision (**which examines the stability of the broader financial system (some have even moved to incorporate climate issues into traditional monetary policy, though this practice is still limited)**)**, with various central banks and regulators establishing internal capacity for climate risk integration. The use of **stress tests** is being adapted to examine the potential impact of climate change on financial institutions and the broader financial system. Different countries have varying approaches to climate-related prudential policies, but bodies like NGFS are promoting best practices. Some **macroprudential measures**, such as carbon countercyclical capital buffers and large exposure limits, have been proposed but not yet widely adopted.

Policies aimed at promoting sustainability are not limited to financial stability, but also include **consumer protection measures** such as **combatting mis-selling or misleading advertising** of sustainable products. One way to enforce these policies is through audits to determine whether products marketed as sustainable are actually delivering on their promises. However, some financial products labeled as sustainable do not appear to have materially different exposures from those not marketed as sustainable, leading to concerns about **greenwashing**. To address this issue, mandatory disclosure and marketing requirements are being considered, and regulatory bodies such as the European Union's securities regulator and the **UK's Financial Conduct Authority** have developed guidelines and principles for fund management firms to ensure that their disclosures are **fair, clear, and not misleading.**

Private-Sector Sustainability Frameworks

The important role played by **corporate and investor groupings** in addressing climate change and promoting sustainability best practices. **The Institutional Investors Group on Climate Change (IIGCC)** is one of the key early groupings in this space, with over 300 members in 22 countries representing over USD 40 trillion in assets under management. **Private-sector-led frameworks** have generally trended towards greater size, resulting in larger groups of groups and umbrella initiatives. **Climate Action 100+** is an investor coalition with 575 members representing over USD 54 trillion in assets under management targeting the world's 100 most heavily emitting publicly listed companies. Other important groupings include the **Net Zero Asset Owners' Alliance** and its counterpart for asset managers. Public and private efforts are increasingly being combined, as seen in the Race to Net Zero and the Glasgow Financial Alliance for Net Zero, which brings together 160 financial firms

representing assets of over USD 70 trillion and requiring the use of science-based guidelines to reach net-zero emissions. The Alliance aims to bring broad-reaching change and help reach Paris Agreement goals.

IPBES's Global Assessment Report on Biodiversity and Ecosystem Services published in 2019 assessed the status and trends of the natural world, the social implications of these trends, their causes, and what actions can be taken to stop biodiversity loss and habitat destruction.

The report highlights that human actions have significantly altered three-quarters of the land-based environment and two-thirds of the marine environment. Land degradation has reduced the productivity of 23% of the global land surface, and pollinator loss puts up to $577 billion in global crops at risk annually. In 2015, 33% of marine fish stocks were being harvested at unsustainable levels. The report also highlights the increase in plastic pollution and the dumping of heavy metals, toxic sludge, and other wastes into the world's waters. The report concludes that negative trends in nature will continue to 2050 and beyond, except with transformative change, due to the projected impacts of increasing land-use change, exploitation of organisms, and climate change.

Climate Groupings

Corporate Groupings		
Name	**Members**	**Description**
TCFD	Cross-sectoral	A set of recommendations on disclosing climate-related risks that has been endorsed by hundreds of firms, both financial and non-financial
Science-Based Targets Initiative	Cross-sectoral	An organization with sector-based targets for decarbonization
Financial Sector Groupings		
Institutional Investors Group for Climate Change (IIGCC)	Asset managers and owners	The organization aims to support and enable the investment com-munity in driving significant and real progress by 2030 toward a net-zero and resilient future through capital allocation, steward-ship, and successful engagement with companies, policymakers, and fellow investors.
Climate Action 100+	Investors of all kinds	A coalition of 575 investors with over USD 54 trillion in assets under management that targets the world's hundred most carbon emissions-intensive publicly listed companies, seeking through collective shareholder engagement to pressure these companies into alignment with climate goals
Net Zero Asset Managers Initiative	Asset owners	37 investors who have committed to aligning their entire portfo-lios with the goal of net-zero greenhouse gas emissions by 2050, including full alignment with a 1.5°C scenario
Net Zero Asset Managers Initiative	Asset managers	Similar to, and founded on, the model of, the asset owner alli-ance, this asset manager initiative is a group of asset managers that support the goal of net-zero greenhouse gas emissions by 2050 and alignment with a 1.5°C scenario
Net Zero Banking Alliance	Global banks	An initiative of global banks that have signed up to align with net-zero greenhouse gas emissions by 2050 and a 1.5°C scenario, with plans for stringent interim targets for 2030
Glasgow Financial Alliance for Net Zero	All financial players	An umbrella group of the three net-zero groupings listed above, and some others, meant to focus the entire financial sector on the goal of net-zero greenhouse gas emissions by 2050.

Source: SCR Certificate (2023)

BULLET POINTS:

- Global Efforts on Climate Policy
  Various attempts have been made to establish international climate policies.
  These efforts have been complicated by disagreements over emissions reductions, collective action difficulties, and differences in responsibilities for emissions between countries.
- Historical Global Agreements on Climate Policy
  The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992 at the Rio Summit.
  The Kyoto Protocol, established in 1997, required high-income countries to reduce emissions by 5% from 1990 levels by 2008–2012.
  The Paris Agreement of 2015 set a target of a 1.5-2°C reduction and relied on peer pressure for non-binding plans.
- Policies for Emissions Reductions
  Carbon pricing, through carbon taxes or cap-and-trade schemes, is a widely used policy.
  Sector-specific policies, such as priority dispatch, feed-in tariffs, net metering, and quota requirements, have also been used.
- Private Sector Transition to a Sustainable Economy
  Societal and cultural trends, as well as sustainability and climate investment policies, are helping to promote the growth of green finance and sustainability-oriented products.
- Financial Supervision and Sustainable Finance
  Many central banks now require financial institutions to integrate climate into governance, risk management, and disclosure, and to undergo climate stress tests.
  Financial policy also supports the growth of sustainable finance through auditing self-described sustainable products and regulatory taxonomies.

PRACTICE QUESTIONS

1. What was the first global agreement on climate change formed in 1992?

   A. The Paris Agreement
   B. The Kyoto Protocol
   C. United Nations Framework Convention on Climate Change (UNFCCC)
   D. None of the above

2. What is the main purpose of the first global agreement on climate change (UNFCCC)?

   A. To reduce emissions
   B. To increase sustainability
   C. To increase private sector practices
   D. To provide a framework for addressing climate change

3. What led to the formation of the Intergovernmental Panel on Climate Change (IPCC)?

   A) The discovery of the greenhouse effect.
   B) The widespread recognition of the human impact on climate change.
   C) The tension between emissions reductions and economic development.
   D) The cooling trend observed in the 1950s and 1960s.

4. What percentage of global cumulative emissions is accounted for by North America as of 2017?

   A. 18%
   B. 29%
   C. 33%
   D. 53%

5. What is carbon pricing?

   A) A form of carbon tax
   B) A range of quota-based regulations
   C) A guaranteed price per unit of electricity generated
   D) A policy aimed at reducing emissions in the transportation sector

6. What is the purpose of America's Pledge launched by some entities in the United States after the decision by President Donald Trump’s administration to withdraw from the Paris Agreement?

   A. To launch a national cap-and-trade system
   B. To advocate for more ambitious climate policy at the subnational level
   C. To bring about the Paris Agreement
   D. To promote the collaboration between the public and private sector in coalitions

7. What is the main goal of EV purchase subsidies?

   A. To reduce the uptake of electric vehicles
   B. To discourage the use of electric vehicles
   C. To encourage the uptake of electric vehicles
   D. To discourage the use of gasoline-powered vehicles

8. What is microprudential supervision in regards to climate change integration?

A. The examination of the stability of the broader financial system
B. The oversight of specific financial institutions for financial soundness
C. The incorporation of climate issues into traditional monetary policy
D. The promotion of collaboration and the sharing of expertise on climate risk a mong financial institutions

9. What is the purpose of the policy enforcement of sustainable investment and disclosure?

A) To ensure financial stability
B) To protect consumers from mis-selling or misleading advertising of products
C) To promote sustainable investments
D) To prevent greenwashing

10. What is the goal of the Net Zero Asset Managers Initiative?

A. To align with sector-based targets for decarbonization
B. To align with net-zero greenhouse gas emissions by 2050
C. To protest slow global progress on combating climate change
D. To disrupt society to highlight the impact of climate change

CHAPTER 5

Green And Sustainable Finance

The concept of **sustainability** has transitioned from development and international public discourse into the private sector, including financial-market participants.

Sustainable finance encompasses various financial activities that consider sustainability across asset classes and different products and services, ranging from corporate loans to mutual funds with shares of sustainable firms offered to retail investors. Sustainable finance, including its subtypes, has been growing rapidly in popularity, with an increase in assets under management invested in sustainable ways and the use of specific sustainable financial instruments like green bonds. Despite the trend, financial firms have been labeling their offerings or practices as "sustainable" without standardized definitions, leading to the evolution of industry standards and oversight.

Green finance focuses on environmental-related risks and opportunities, while climate finance pertains solely to financial flows relating to climate change, historically associated more with public sector funding than private sector.

Climate finance refers exclusively to financial flows relating to climate change, whether mitigation or adaptation, but it has historically been associated with the public sector more than with private-sector funding.

According to the **Global Sustainable Investing Alliance**, **sustainably invested global assets** under management reached **USD 30.7 trillion in 2018**, growing by 35% in just two years. Japan saw the greatest growth, with sustainable assets tripling every year on average. The survey also indicates that a large proportion of all professionally managed assets are now managed sustainably, with around half in Canada and Europe, and a quarter in the United States. However, note that the GSIA definition includes **negative/exclusionary screening** as a type of sustainable investing, accounting for around half of the total.

The Climate Policy Initiative provides a comprehensive dataset to examine financial flows used for climate change-related projects and investments. The growth of investor groupings and coalitions dedicated to sustainability and climate issues has also contributed to the surge in sustainable and climate investing. For instance, the Net Zero Asset Owner Coalition grew from 12 members representing USD 2.4 trillion in assets to 37 members with 5.7 trillion in under two years. The growth in sustainable finance instruments and financial products is another popular way to look at growth in sustainable finance.

The CPI's (the Climate Policy Initiative) tallies show the large **majority of financing is domestic**, with 78% of financing within higher-income OECD countries from domestic sources, and 74% in non-OECD countries, which are generally emerging markets.

Sustainable and Green Financial Products

Green, Social, and Sustainable Bonds

Sustainable financial instruments and products are examined, which take different forms and involve different parties.

Green or sustainable loans are similar to typical corporate loans and usually involve a small number of banks and a borrowing company.

Green and other sustainable bonds are used by public and private entities to raise funds, underwritten by banks and traded on secondary markets.

Sustainable or green fund products are also available for institutional or retail investors, which may consist of sustainable instruments or other assets.

Social bonds are bonds with earmarked proceeds for projects that will bring social benefits. As with green bonds, the impetus initially came from a public-sector financial institution, in this case Spain's Instituto de Crédito, which issued the first social bond in 2015 to finance small and medium enterprises in disadvantaged parts of Spain.

Sustainable financial products can be divided into three broad categories, including those with **earmarked and ring-fenced proceeds**, those with a **sustainability-linked instrument**, and those with **sustainability as a selection criterion**.

Green bonds are the most common sustainable bond, and they differ from traditional bonds by having labeled proceeds that are ring-fenced and reported to bondholders. The market for green bonds has grown since its beginnings with multilateral development banks, and it is largely self-policed. In addition to green bonds, other sustainable bonds, including social bonds and sustainability bonds, have been developed to address social and environmental objectives.

Sustainability bonds are a combination of the two, in that they are meant to simultaneously address both environmen-tal and social objectives.

SDG bonds linked to UN Sustainable Development Goals are another type of labeled bond.

The [Green Bond Principles]:

The first component is **the use of proceeds**, which requires the funds to be used for environmental projects that provide clear benefits. The second component is the **process for project evaluation and selection,** which includes identifying eligible green projects and any applicable exclusion criteria. The third component is **the management of proceeds**, which requires the issuer to credit the funds to a sub-account and track their use for green projects. The fourth component is **reporting,** which requires issuers to provide up-to-date information on the allocation of proceeds and the impact of the projects.

Green Loans Green

Green loans are loans that are specifically intended for environmental and climate-related projects. According to the **Green Loan Principles** set out by the Loan Market Association, **green loans** are expected to ring-fence the funds and borrowers are expected to report on their use. However, different jurisdictions may have slightly different rules for green loans, as seen in China where green loans were adopted in response to the government's 2007 Green Credit Policy. This policy required banks to provide green credit for projects related to environmental protection, emission reduction, and energy conservation. Chinese green loans have grown significantly since 2013, reaching 10.8% of banks'

balance sheets by the end of 2019, with a total of over RMB 10.6 trillion. Green loans in China have mainly been used for clean transport and clean energy, and they have performed better than conventional loans, with a lower non-performing loan ratio.

However, the performance of green loans varies between large state-owned banks and smaller city/regional level commercial banks, with the former showing a negative association between green loans and credit risk and the latter showing a positive association. Globally, green loan underwriting has grown from USD 30 billion in 2015 to USD 90 billion in 2019, with the power sector being the largest recipient of green loans. In contrast, the sustainability-linked loans have grown even more quickly and have exceeded the total volume of green bonds.

Sustainability-Linked Bonds and Loans

Sustainability-linked bonds (SLB) and **sustainability-linked loans (SLL)** are examples of this innovation, where the coupon paid or the interest rate on the loan is tied to the issuer or company's achievement of pre-agreed sustainability targets, also known as **key performance indicators (KPIs).** Unlike green bonds and loans, sustainability-linked instruments are being adopted by various sectors and are rapidly growing in volume.

Despite being relatively new, **the Sustainability-Linked Loan Principles and the Sustainability-Linked Bond Principles** have gained industry-wide adoption and have guidelines for the market. These principles have been developed by loan-market umbrella organizations and ICMA, the same body that developed the Green Bond Principles. The SLL and SLB principles are being further coordinated for better alignment across bonds and loans, and have specific elements that differ from the Green Bond Principles, particularly in terms of the stringency requirements for KPIs and sustainability performance targets.

The Sustainability-Linked Loan Principles (SLLP) and the Sustainability-Linked Bond Principles (SLBP), both principles aim to incentivize borrowers or issuers to achieve predetermined sustainability performance objectives or sustainability outcomes by aligning loan terms or bond characteristics to their sustainability performance. The SLLP emphasizes measuring improvements in the borrower's sustainability profile through sustainability performance targets (SPTs), while the SLBP emphasizes the selection of key performance indicators (KPIs) and the calibration of SPTs to represent a material improvement beyond business as usual trajectories. Both principles also include reporting and verification components to ensure transparency and accountability.

Sustainable and Green Funds

Sustainable financial products for end investors, both institutional and retail, have become increasingly popular. Investment vehicles such as **mutual funds, exchange-traded funds (ETFs), and other funds market** themselves as being sustainable. There are various ways in which these funds can be sustainable, including through investments in **labeled sustainable financial instruments like green bond funds** or **shares of companies engaged in sustainable activities**. The determination of whether a company is sustainable is often done through the use of **ESG scores** or **ratings**, which can be determined by a fund manager or an index provider. Some exchanges also have their own green labels.

ETFs have become a rapidly growing segment of the funds market, and the largest sustainable equity ETF is a fund of U.S. equities run by BlackRock's iShares division, which excludes firms involved in certain industries and has high ESG scores. The ten largest sustainable ETFs have a total of USD 38.3

billion in assets as of April 2021, compared to the largest ETF, which has over USD 360 billion in assets.

ESG and Climate Integration in Investing

The integration of **climate and ESG issues** into investment and lending decisions begins with the use of metrics, such as **ESG and climate risk and exposure scores**.

Scores and ratings provided by data providers, such as **Bloomberg, Refinitiv, MSCI, Sustainalytics, FTSE, ISS, and Vigeo Eiris**, are commonly used to assess the performance of investee or debtor companies.

ESG ratings aim to provide an overall assessment of a company's sustainability using a scoring approach based on a wide range of quantitative and qualitative indicators. However, **the lack of standardization and proprietary methods** used to calculate these scores, along with substantial differences in methodologies among rating providers, make it difficult to compare ESG scores.

The number of ESG ratings has grown more than fivefold globally between 2010 and 2019, with an estimated 600 ESG ratings available. The **available data** on climate change is also complex, with transition risk and physical climate risk scores having similar shortcomings to ESG scores.

Investors and lenders are increasingly incorporating ESG and climate considerations into their operations, either through a separate ESG or sustainability division or full ESG integration where every analyst and decision-maker is trained and applies ESG to their job function.

ESG data can be collected from **primary courses**: **external providers**, **discussions with the company, corporate sustainability reports, and regulatory disclosures**. **ESG integration** is often paired with **engagement with companies and decisions** about over or underweights in loan books and investment portfolios. Some investors have ruled out certain kinds of investments on ESG grounds, such as excluding sectors like weapons, tobacco, alcohol, and gambling, and phasing out new coal lending and implementing restrictions, exclusions, or additional requirements for financing certain projects related to offshore oil & gas, hydraulic fracturing, and Arctic oil.

Investor engagement with company management around sustainability has become an important way for the financial sector to bring about corporate change.

Engagement is used for various reasons, including **gaining credibility with clients, mitigating financial risks, and aligning with corporate strategy. Shareholder engagement** initially focused on pushing companies to disclose ESG performance metrics and sustainability policies, but has now evolved to demand that investee companies align with certain targets, such as Paris alignment or implementing a net-zero emissions-compatible business model.

Engagement is often paired with the **threat of divestment**, but this requires market power and flexibility and is most effective for larger asset managers or hedge funds. Shareholder engagement has been successful in achieving compliance and increasing ESG ratings of targeted firms, with success rates ranging from 18% to 60%. Engagement is often part of larger coalitions, such as **Climate Action 100+**, which can exert more pressure on management than individual investors.

Taxonomies:

The increasing popularity of sustainable finance has created a need for standardized definitions. Currently, industry associations have developed **voluntary guidelines and frameworks** through a **bottom-up approach**.

However, regulatory involvement is also growing, with different jurisdictions having different regulatory frameworks and traditions. In the UK, the focus is on audits to ensure that products marketed as sustainable are living up to their promises, while in the EU, regulators are specifying definitions and limits in advance. This indirect regulatory action can significantly affect market practices. **Financial products, such as green bonds and sustainability-linked loans**, have been primarily developed by financial market participants, with some limited regulatory involvement, such as the EU's efforts to create a regulatory green bond standard. **Regulatory initiatives**, such as the **Network for Greening the Financial System** and the recognition of sustainability-linked bonds as collateral, have also encouraged the growth of sustainable finance.

In recent years, there has been a trend towards increased **disclosure requirements** for companies, often through regulatory action. In the **EU**, certain large companies and public interest firms are **required to disclose ESG-related information**, and this directive will be expanded in 2021 to include all companies with more than 500 employees. In the **UK, listed companies have been required to report on greenhouse gas emissions and diversity since 2006**, and starting in 2022, all listed companies and limited liability partnerships must report on climate risk in line with TCFD recommendations. **China's** securities regulator has mandated that all **listed companies disclose ESG risks,** and in **Canada, listed companies must report on some ESG parameters related to diversity, with companies receiving government support during the COVID-19 pandemic** required to start TCFD reporting. Some disclosure requirements are imposed by exchanges themselves, with at least 25 exchanges worldwide requiring ESG disclosure for companies to be listed.

Regulatory activity in sustainable finance is also focused on underlying economic activity. **China** has historically allowed **"clean coal"** and other types of **"clean utilization of fossil fuels"** to be financed **by green bonds**, while **Western market-led standards have not allowed fossil fuel financing**. However, in 2020, China proposed excluding clean fossil fuels from its revised standard to align with other countries and market-led rules. Regulators are also defining sustainable activities in greater detail, with the EU leading the way with its Taxonomy, which sets performance thresholds for economic activities in various sectors and subsectors, based on their contribution to environmental objectives. Other countries are developing their own taxonomies, with many looking to the EU as a model. There is an incentive to harmonize definitions on sustainable economic activities, as there has been with sustainable investment products. In April 2021, China and the EU announced plans to harmonize taxonomies and develop a jointly recognized classification system for sustainable businesses.

BULLET POINTS:

- Sustainable finance pertains to any financial product or service that takes sustainability into consideration.
- Green finance, on the other hand, specifically focuses on environmental financing, while climate finance pertains to climate-related financing, often using public-sector funds. Both sustainable finance and climate finance have experienced substantial growth in recent years. The largest contributor of financial flows for climate projects are public-sector development banks. Private-sector coalitions related to climate and sustainability have also grown in membership and total size.
- Green bonds are a type of bond that finances environmental projects, with separate labeling and ring-fenced proceeds, and the planned use of proceeds reported to bondholders before and after implementation.
- Other sustainable financial instruments include social bonds for social benefit, sustainability bonds for dual environmental and social benefits, green loans, and sustainability-linked bonds and loans that tie interest rates to sustainability targets.
- The sustainable funds market, composed of funds with sustainable instruments or shares in sustainable companies, is sizeable and expanding.
- Many financial institutions integrate environmental, social, and governance (ESG) data into their investment and lending decisions, and engage with investee companies.
- As the market matures, regulations become more involved and definitions are standardized across borders.

PRACTICE QUESTIONS

1. What type of financial organizations have embraced sustainable finance?

   A. Mainstream banks and asset managers
   B. Small, specialist pure-play green financial firms
   C. Stock exchanges and ratings agencies
   D. All of the above

2. What type of sustainable investing accounts for around half of the total in the GSIA survey?

   A. ESG integration
   B. Shareholder engagement
   C. Negative/exclusionary screening
   D. Impact investing

3. What was the growth rate of sustainable assets from 2016 to 2018?
   A. 35%
   B. 40%
   C. 50%
   D. 60%

4. What is the main purpose of tracking climate finance flows by the Climate Policy Initiative (CPI)?

   A) To measure the growth of climate finance
   B) To track the amount of climate finance
   C) To provide an in-depth analysis of climate finance
   D) To provide a simple amount of climate finance

5. What is the origin of the majority of financing in higher-income OECD countries?

   A) Domestic sources
   B) Cross-border investments
   C) Private financial institutions
   D) Governments

6. What was the founding year of the "Climate Action 100+"?

   A) 2019
   B) 2017
   C) 2020-2021
   D) 2006

7. What is a social bond?

   A. A bond used for environmental projects
   B. A bond used for public-sector financial institutions
   C. A bond used for social benefits
   D. A bond used for small and medium enterprises

8. Who is involved in the agreement for green or sustainability loans?

A. A small number of banks and a borrowing company
B. All kinds of private and public entities
C. Institutional or retail end investors
D. The management of a company

9. What is the difference between green bonds and typical corporate or government bonds?

A. Green bonds are labeled separately
B. The proceeds of green bonds are ring-fenced
C. The use of proceeds of green bonds is reported to prospective and current bondholders
D. All of the above

10. What is the KPI tied to the sustainability-linked loan of Volution?
A) Percentage of sales revenue from low-carbon products
B) Percentage of electricity sourced from renewable energy
C) GHG emissions
D) Gender diversity in the workforce

CHAPTER 6

Micro (Company-Level) Climate Risks:

The practice of **risk management** involves **monitoring, measuring, and managing exposures to reduce the potential impacts of uncertain events.** Climate risk affects corporations and portfolios in various ways, and proactive climate risk management can help mitigate these impacts. **Climate risk** management, when practiced proactively, can help mitigate the impacts of climate change, both from physical impacts and transition impacts, on a financial institution's portfolio or corporation's operations.

Types of Risks

Risk Type	Risk Metrics	Micro-level	Macro-level
Operational Risk	-Proportion of facilities in risky areas -Level of company preparedness	**Physical risk** leading to more frequent, more severe extreme weather can cause property damage and business interruption, both to a business' own facilities and to supply chains. Heat can also affect worker productivity. **Transition risk** can transmit to operational risk in case of abrupt policy changes leading to facility shutdowns.	**LIMITED**—Only under a specific set of circumstances, such as where a sector has high geographic concentration
Credit Risk	-Probability of default (PD) -Loss given default (LGD) -Exposure at default (EAD)	**Physical risk** causing property dam-age and business interruption can lead to loss of revenues and lower profits, worsening a firm's financial position and increasing probability of default. **Transition risk** causing asset stranding can worsen a firm's financial position, increasing its probability of default, and increasing the loss given default for a	**SIGNIFICANT—** Sector-wide asset stranding or changes in demand can impact sec-tor revenues and increase sector-level PD, posing financial stability risks in the case of important sectors and for exposed financial institutions.

		lender given the lower asset valuations.	
Liquidity Risk	-Loan to deposit ratio (banks) -Liquidity ratios -Bid-ask spread (markets)	Abrupt physical and transition risk-related events such as natural disasters or abrupt policy changes can prompt sharp repricing and sudden market re-evaluation of firms' viability, leading to liquidity shocks. This can lead to widening of bid-ask spreads. Abrupt climate events can prompt large demand for deposit withdrawals at banks, raising their loan-to-deposit ratios.	**SIGNIFICANT**—A "climate Minsky moment" could cause abrupt and wide enough repricing and dislocation to constitute a market liquidity shock.
Underwriting/insurance Risk	-[Change in] insurance premiums -Availability of insurance	**Physical risk** can lead to higher insurance premiums for corporations, or, in more severe cases, for certain facilities in extremely vulnerable areas to become uninsurable, with no insurance available. **Transition risk** can lead to less insur-ance availability, as some insurers refuse to underwrite certain kinds of activities and facilities, such as ther-mal coal power plants.	**SIGNIFICANT**—If a number of insurers withdraw or refuse coverage, this might leave firms completely without coverage, potentially amplifying risks to financial stability.
Market Risk	-[Weighted average] carbon intensity -[Climate] Value at Risk -Portfolio risk scores	**Physical and transition risk** can become more widely incorporated in asset prices, both through abrupt repricing as well as more gradu-ally. Large-scale shifts in input and product markets affect non-financial corporations. Shifts in asset prices increase the risk of financial institutions' portfolios.	**SIGNIFICANT**—Climate risk is expected to produce sector-and market-wide repricing of many if not most assets and commodities, causing disloca-tion and potential systemic risk.
Sovereign Risk	-Proportion of budget revenues from fossil fuels -Vulnerability to physical climate risks	**Physical risk** can cause countries that are particularly vulnerable, such as Bangladesh, to have higher costs of damage and lower GDP growth, hampering long-term ability to repay. **Transition risk**	**MIXED**—Many countries have diversified economies and geographies, but some countries are heavily exposed to physical or transition risk and are likely to be severely affected.

		can heavily affect countries reliant on fossil-fuel production for a substantial proportion of GDP and of government tax revenue.	

Source: SCR Certificate (2023)

Operational Risk

Operational risk refers to the inherent dangers associated with conducting business and represents potential losses stemming from insufficient or unsuccessful internal processes, systems, human error, or external events like severe weather or terrorist attacks. These various sources of operational risk are often viewed as subcategories, **encompassing external risk (from outside events), systems risk, people risk (from human error), internal process risk, and legal, strategic, and reputational risks.**

Metrics used to assess these risks include **the percentage of facilities situated in vulnerable locations (for external risk) and several measures of organizational preparedness.**

Climate risk can influence people risk in several ways. **Insufficient staff training or management focus on physical and transition climate effects** can result in these concerns being overlooked or downplayed within a company's operations, potentially causing losses. Another way climate risk can become people risk is more direct—**through the detrimental effects of excessive heat on worker productivity and sharpness.**

The transmission of climate risk into internal process risk is akin to that of people risk—if a bank's or another corporation's internal processes and procedures do not sufficiently consider climate risk, it can impact portfolios and facilities more profoundly than expected.

Strategic risk arises when poor business decisions regarding the failure to align business practices with the net-zero transition or adaptation to the physical consequences of climate change can pose significant risks compared to competitors that do take mitigating and adaptive measures.

Physical climate hazards, such as floods or fires, can affect data centers and other system infrastructures, thereby posing **systems risk** to a corporation or financial institution.

Reputational risk can severely impact institutions associated with "dirty" industries that are perceived as having lost their social license to operate.

Climate risk has a significant impact on operational risk, particularly in terms of external risk. **Extreme climate events, such as floods, storms, and wildfires, or gradual climate changes, like rising sea levels**, can damage or even destroy facilities, supply chains, warehouses, and other critical assets of a company or financial institution. Unlike traditional definitions of external risk, where the impact is considered beyond a company's control, combining climate models with comprehensive data can provide some level of predictability regarding which physical assets will be impacted by these external risks.

Credit Risk

Credit risk evaluates the creditworthiness or the capacity of a borrower to repay a loan. Essential metrics for assessing credit risk, particularly for banks, involve **the probability of default (PD) and the loss given default (LGD),** which refers to the percentage of value recovered following a default. PD is the most universal measure of credit risk, applicable beyond banks (e.g., to bond markets).

LGD is anticipated to be highly sector-specific, necessitating significant customization. Generally, climate risk is expected to shift the entire PD risk distribution for a borrower.

One significant transmission channel connecting climate to credit risk goes through operational risk. For instance, a company with factories, warehouses, or supply chains particularly susceptible to extreme weather impacts (physical risk) or abrupt policy changes (abrupt transition risk) will experience greater business interruption, resulting in revenue and profit losses. This reduces the company's ability to repay loans compared to a non-exposed company, translating into increased PD and credit risk for a lender. **Project finance** associated with a specifically vulnerable asset, like a flood-prone warehouse, would be subject to even higher PD and LGD compared to the exposure of an entire company owning a mix of vulnerable and non-vulnerable assets.

Another crucial channel operates through valuation effects, such as asset stranding, which can result from physical or transition risk. The oil & gas sector exemplifies an industry affected by the stranded asset transmission channel.

A final, related channel involves pricing effects on both input (raw materials) and output (products) markets. If climate risk causes a company's raw materials to become more expensive or devalues its products, this can also increase its credit risk. Conversely, pricing effects can reduce a company's credit risk. Companies in the mining sector extracting minerals crucial for mass electrification, like copper for wiring or lithium for lithium-ion batteries, can profit from higher commodity prices, generate increased revenues and profits, and become more creditworthy than without climate change.

Policy considerations concerning the escalation of credit risk due to climate risk are increasingly being integrated by major credit ratings agencies, which serve as vital adjudicators of credit risk for financial markets.

The growth of sustainability-linked bonds and loans exemplifies the financial industry internalizing the connection between **credit risk and sustainability performance**. Offering a **lower loan rate or reducing the coupon on a bond** that an issuer must pay in exchange for meeting sustainability targets, as these instruments do, implicitly acknowledges the corollary: that underperforming in this aspect raises credit risk.

Liquidity Risk

Liquidity risk pertains to the loss of access to liquidity—the capacity to swiftly and effortlessly convert assets into cash. For banks, liquidity risk has a specific meaning, as banks' business models rely on liquidity transformation: Banks accept short-term deposits and issue long-term loans.

Crucial metrics for liquidity risk encompass **loan-to-deposit ratios (particularly for banks) and bid-ask spreads (especially for markets).** For example, climate risk drivers can cause depositors to withdraw deposits and debtors to utilize credit lines simultaneously, substantially increasing (worsening) loan-to-deposit ratios (empirical evidence indicates that this can happen due to physical climate risks, specifically following natural disasters).

Market dislocations present a more significant source of risk through their macro effects, as well as their impact on financial stability and the potential for "Minsky moments."

For an individual non-financial company, liquidity risk only manifests as a result of climate risk under particular circumstances. Climate-related risks can considerably affect a company's financial health in terms of both liquidity risk and credit risk. Although acute events like hurricanes can lead to a sudden reassessment of a company's viability, climate risks generally filter through to companies gradually, resulting in higher credit risk and an increased cost of capital. Consequently, it is increasingly vital for companies to integrate climate risk into their risk management strategies and for investors to take climate risk into account when making investment decisions.

Underwriting risk

While **underwriting risk** directly impacts only the insurance sector, it is essential to highlight it as a type of risk influenced by climate risk, particularly physical climate risk, since numerous corporations and financial institutions depend on insurance coverage as a vital component of their risk-mitigation strategies.

Crucial metrics for assessing underwriting risk from a corporation's viewpoint include changes in **insurance premiums and insurance availability.**

Insurance functions optimally when a large group of participants (e.g., motorists, corporations, homeowners) each have a small and nearly equal chance of encountering misfortune, and when accidents or other losses adhere to predictable patterns discernable from historical data.

The issue with climate risk, particularly specific types of physical climate risk, is that risks become so concentrated that underwriting affected facilities and properties in those areas may become economically unviable.

For shorter return periods, insurers would need to charge very high premiums to break even; for example, a ten-year return period (i.e., a 10% annual chance of occurrence) of a total destruction event in a specific location would necessitate an insurance premium of at least 10% of the insured property's value.

Large insurers with diversified exposures can cross-subsidize to some extent, but smaller, regional insurers lacking geographical diversity do not have this luxury. (Insurers can occasionally offload part of their risk to reinsurers, but these firms are also becoming more cautious about accepting climate risk.)

Climate transition risk can also affect underwriting risk. The policy, operational, and technological changes needed for a net-zero economy transition could lead to litigation against fossil-fuel companies, which could then transmit into insurance through general liability or "directors and officers" (D&O) policies, where insurance assumes (at least partially) the financial risks of a firm being sued.

Increases in underwriting risk can also influence other types of risk. For instance, if a company can no longer secure insurance coverage for physical damage, business interruption, or directors' liability, it cannot use insurance as a resilience and buffer mechanism, which further escalates operational risk. This, in turn, heightens its credit risk from a lender's perspective.

Macro Climate Risk

Operational Risk

Physical climate impacts causing operational risk to manifest across various companies can produce ripple effects throughout supply chains, markets, customers, and financial counterparties. Typically, a specific set of circumstances, such as geographic concentration and supply chain pinch points, is required for operational risk to have such extensive effects. Climate change-induced counterparty credit risk can directly transmit to the financial sector, potentially threatening financial stability if widespread enough.

Credit Risk

Numerous climate risk drivers that can increase credit risk for individual firms can also affect entire sectors. In sectors like utilities (those still dependent on fossil power plants) or oil & gas, sector-wide asset stranding is anticipated or has already occurred, raising credit risk. Altered demand and cost structures due to climate-related pressures can impact companies' revenues and profits, as can physical climate impacts causing business interruption, both leading to widespread increases in credit risk. For financial institutions heavily exposed to these sectors, this can pose a risk to the institution's soundness. If exposures span the financial sector, increased company-level credit risk can become a threat to financial stability.

Liquidity Risk

Considering the extensive reach and potential severity of climate impacts, liquidity risk can be a source of systemic risk to the banking sector and therefore endanger financial stability. If a significant number of households, corporations, and financial firms dramatically increase their demand for precautionary liquidity following a severe natural disaster, this can be systemic enough to necessitate central bank intervention. Another potentially concerning source of systemic liquidity risk is a "climate Minsky moment," a sudden, significant collapse of asset values. If large-scale market changes caused by climate risk don't occur suddenly enough to cause a crisis, they can still be problematic. These changes are classified as "market risk," distinct from "liquidity risk." Market risk implies that the value of investments or assets can change due to external factors like climate risk, while liquidity risk relates to a company's ability to access cash or credit when needed. Climate risk can cause market risk, affecting the value of investments or assets, but not necessarily leading to a liquidity crisis.

Insurance Risk

Insurance risks, particularly the threat of uninsurability when insurers deem climate risks too great to underwrite, can have systemic effects. If a large number of insurers significantly increase premiums or completely withdraw coverage of certain climate-related risks, this could leave households and firms without coverage, potentially amplifying risks to financial stability.

Market Risk

At the systemic level, climate risk translates into market risk through repricing and dislocation effects and asset stranding. The "repricing effect" refers to a situation where the value of assets, like houses, stocks, or bonds, changes quickly and tangibly due to anticipated yet unrealized climate-related risks. For instance, if investors believe that a company's operations might be affected by future climate-related events, they may sell their shares in that company, causing the share price to drop. Most market actors are more concerned about quicker, more abrupt pricing shocks and increased volatility,

reflected in key metrics like Value at Risk (VaR). Other metrics help individual institutions assess their exposure to climate-related market risk, such as the weighted average carbon intensity of a portfolio (a proxy for transition risk exposure) or portfolio-level physical risk scores. Standard Value at Risk is a metric for quantifying the level of financial risk in a firm, portfolio, or investment and estimating a bad outcome. MSCI, a data provider, offers a commercial tool called "Climate Value at Risk." Climate risk drivers (physical and transition risk) can reveal new information about future conditions, downward price shocks, and increased market volatility in traded assets. It's also possible that it could lead to a (partial) breakdown of asset correlation, reducing hedge effectiveness and challenging banks' abilities to actively manage risks. Incorporating climate risk into asset prices might also reduce risks to financial stability.

Incorporating climate risk into asset prices might help financial markets better prepare for and react to climate-related events. As the financial industry becomes more aware of the potential impacts of climate change, market participants are likely to adjust their investment strategies and risk management approaches accordingly. This could lead to more accurate pricing of climate-related risks, potentially reducing the likelihood of abrupt shocks or excessive volatility in the markets.

Sovereign Risk

Regarding physical risk, assessing a country begins, similar to a company, with geographic exposures, such as the presence or percentage of low-lying coastal regions susceptible to sea level rise and coastal flooding. However, comprehending entire nations also involves examining the size and sectoral composition of their economies, the ability to develop adaptive policies and responses to climate change, debt accessibility and affordability, and specific policy decisions. As early as 2016, Moody's, the credit ratings agency, established a physical risk methodology for sovereigns and identified India, Pakistan, Vietnam, Cambodia, and much of Central America and sub-Saharan Africa as the most vulnerable.

Concerning transition risk effects on sovereigns, discussions primarily revolve around countries' dependence on fossil fuel and other carbon-intensive exports.

As stricter climate policies, innovative technologies, and preference shifts decrease the demand for fossil fuels, states heavily reliant on fossil fuel exports may become "stranded nations."

Climate Risk Measurement: Data and Analysis

Transition risk necessitates accurate asset-level and company-level data on greenhouse gas emissions, as well as information on policy landscapes, technological changes, and consumer preferences to capture the various drivers of transition risk.

Physical risk demands data on current and future physical hazards, derived from a combination of historical data and climate models; topographical data and locational data of assets; and information on vulnerability and adaptive capacity. (Physical risks: Weather and climate data and models are essential for understanding physical hazards; topographical maps and geolocation data for comprehending exposure; and data on flood defenses and other adaptive measures for grasping vulnerability.)

Transition risk begins with measuring GHG emissions to achieve a net-zero economy. The Greenhouse Gas (GHG) Protocol offers a widely accepted method for categorizing emissions. Scope 1 encompasses emissions resulting directly from a company's operations; Scope 2 covers upstream

emissions from purchased electricity, heating, and cooling; and Scope 3 includes all other upstream emissions from supply chains and downstream emissions resulting from the use or disposal of products and services sold by the company.

These carbon emissions data, or corporate carbon footprints, have certain limitations. Most data currently come from self-reporting by companies themselves through mechanisms such as an annual questionnaire by CDP, an NGO formerly known as the Carbon Disclosure Project. These voluntary disclosures are typically unaudited and vary in breadth and detail.

Many companies do not disclose all (only Scope 1 and 2) emissions. Few firms disclose all of the Scope 1, 2, and 3 emissions.

To overcome **data availability limitations**, some data providers model the predicted emissions of non- or partial-disclosing companies based on sectoral data. **At the portfolio level**, **double-counting issues** also need to be considered; for example, an industrial firm's Scope 2 emissions (from purchased electricity) would be counted as part of the electricity utility's Scope 1.

However, **transition risk is not only about current emissions** but also about whether companies have **robust and credible plans to reduce emissions in the future** (align their corporate emissions trajectories with the Paris Agreement 2°C target or net-zero emissions by 2050).

Transition risk analysis typically requires the use of **climate scenarios**. Transition risk implies that even data on both emissions and emissions trajectories are insufficient without understanding the drivers of transition risk, such as policies, changing technologies, shifts in consumer preferences, and market sentiment.

International agencies like the **International Energy Agency (IEA)** or **International Renewable Energy Agency (IRENA);** specialist consultancies such as Bloomberg New Energy Finance or Rystad Energy; and large data firms like S&P Global offer quantitative and qualitative data on policies and new technologies, for example, by providing data on the learning curves and pricing of solar modules or lithium-ion batteries**.**

Company-Level Physical Risk Data

The fundamental data for assessing physical hazards comes from global climate models developed by climate scientists for the periodic reports of the IPCC. To make these models relevant and usable for companies or investors, the outputs from different models must be reconciled, downscaled to provide regional or local estimates, and then combined with exposure and vulnerability data.

Eight firms or organizations offer investors physical climate risk analysis tools: Acclimatise, Moody's, WRI, Four Twenty Seven (acquired by Moody's, the credit rating agency), Carbone 4, Carbon Delta (acquired by MSCI, a data firm), Mercer, and a collaboration between Ecolab, Trucost, and Microsoft (ClimINVEST, 2019). Other consultancies, such as XDI or South Pole Group, have been employed by investors for customized, ad hoc projects related to physical climate risk, but they do not provide scores or analysis for widespread use.

By combining climate hazard data with the locations of companies' factories and warehouses and an estimate of vulnerability, physical climate risk scores can inform investors about the relative physical risk of their investments.

Portfolio-Level Analysis (Transition and Physical)

Portfolio-level analysis, in contrast to asset- or firm-level analysis, is the type of analysis most relevant to a financial counterparty, like a lender or an investor. For transition risks, many portfolio-level approaches begin with figures proportional to an amount, either of invested capital or corporate revenues, rather than total absolute emissions. Two common metrics are carbon intensity, or

greenhouse gas emissions normalized by portfolio market value (e.g., tons of CO2 equivalent/million USD invested), and weighted average carbon intensity (tCO2e/million USD of revenues).

Other methodologies assign a temperature or "warming potential" to an entire portfolio. Risk-based approaches to transition risk include stress testing (e.g., modeling how a portfolio responds to a transition shock such as a sudden increase in carbon tax). However, most stress testing on climate risks, particularly transition risks, relies heavily on scenario-based analysis.

For physical risks, portfolios composed of individual physical assets like buildings or factories can be evaluated fairly easily as a whole, examining which assets are exposed to specific hazards using free and commercial tools. Nevertheless, reasonably aggregating and evaluating portfolio-level physical risk is challenging for equity or bond portfolios, where exposure is to entire companies (including all their facilities and supply chains). Some tools provide (rough) estimates of physical hazards in monetary terms. For example, a framework called "Climate Value at Risk (VAR)" from Carbon Delta, now part of MSCI, offers a quantitative estimate of the expected financial losses or gains from climate risks and opportunities.

Enterprise Risk Management

Enterprise risk management (ERM) refers to comprehensive approaches for managing risk across and within an organization, like a large corporation. One of the most popular frameworks for ERM was created by **the Committee of Sponsoring Organizations of the Treadway Commission (COSO),** initially introduced in 2004 and updated periodically. The most recent version, from 2017, comprises actions and responsibilities spanning five broad areas, including **governance, strategy, performance, review, and communication, along with subcategories under each.**

ERM encompasses the **"culture, capabilities, and practices that organizations integrate with strategy-setting."** It is not merely about compiling a list of risks, implementing internal controls, or using checklists. Instead, COSO contends, it is a holistic approach operating throughout an entire company.

The Task Force on Climate-related Financial Disclosures (TCFD) has been a primary driver in framing climate change as a risk source, promoting disclosure to investors and other stakeholders, and advocating scenario analysis as a methodological tool.

The Network for Greening the Financial System (NGFS) is a consortium of central banks and supervisors. On a national level, some countries have national-level entities, such as the Climate Financial Risk Forum (CFRF) in the UK, where the country's two main financial regulators collaborate with industry representatives.

The CFRF (Climate Financial Risk Forum) has been instrumental in categorizing and framing climate risk management, and this section also partially relies on its CFRF classifications.

Risk Governance and Culture

Effective risk governance begins at the top, **with the board and senior executives**. Robust risk governance can promote understanding, disseminate knowledge, ensure true accountability at all organizational levels, and enhance a firm's resilience. Optimal governance arrangements often involve multiple layers of employees and internal processes.

A corporation's culture, as defined by COSO, encompasses the "**attitudes, behaviors, and understanding about risk [...]** that influence the decisions of management and personnel and reflect the mission, vision, and core values of the organization." To incorporate climate change and sustainability into a company's culture, its mission and core values should address climate risk drivers; senior leadership should communicate climate expectations; and employee behaviors and initiatives aligned with strategic corporate priorities should be supported and encouraged**.**

Strategy and Setting Objectives, Goals, and Targets

Corporate strategy, referring to high-level decisions regarding an organization's priorities and mission, is a vital component of a comprehensive ERM approach and any enterprise's response to climate risk drivers. A crucial prerequisite for strategic decisions is the strategic landscape evaluation, especially concerning climate issues.

Understanding the complete business context of climate risk necessitates comprehension of the **external environment and megatrends, such as expected physical, societal, and macroeconomic impacts of climate change.** It also requires an understanding of how a specific company's inputs, business activities, and outputs are affected by climate change.

COSO and the World Business Council for Sustainable Development (WBCSD) **recommend starting with megatrend analysis** and proceeding further using tools like **SWOT analysis, impact mapping, and materiality assessment.**

Two other key strategy components concerning climate change, emphasized by the TCFD, are time horizons and outcome variance by scenario, which can be addressed through scenario analysis.

Strategy also involves setting goals and targets. In terms of climate change, corporate goal-setting often focuses on climate change mitigation and emissions commitments, including alignment with net-zero emissions or even commitments to being carbon negative (e.g., Microsoft has pledged to remove all carbon dioxide attributable to its historical operations from the atmosphere by 2050).

These goals may be driven by various motivations, aiming for different risk objectives, such as corporate social responsibility and adherence to peers and societal norms (avoiding reputational risk) or protection from asset valuation through proactive corporate transition (avoiding stranded asset and market risk).

Performance: Tracking and Measuring Risks

In accordance with the COSO ERM framework, monitoring performance for ESG and climate risks comprises three sub-components:

1. **risk identification** (involves investigating the transmission channels of climate risk drivers into financial risk and pinpointing the most relevant ones for a specific organizatiom. Risk identification entails outlining the potential impact on business operations and strategy);

2. **risk assessment** (entails collecting data on the actual scope of these risks. Financial institutions typically conduct this analysis at a counterparty level;

3. **prioritization** (is particularly crucial in an ERM context, as any large enterprise will be exposed to numerous risks, and it is essential to rank them in order of importance. Ranking methods include ranking by likelihood of occurrence, adaptability and complexity, or severity.

Another approach for prioritizing risks is filtering by the risks the company can actually control), and **implementing risk responses**:

- **Acceptance** (acknowledging its impact, but not taking action);
- **Avoidance** (refers to eliminating the risk entirely, along with anything related to it);
- **Pursuit** (involves turning risks into opportunities);
- **Reduction** (risk through improvements in processes, systems, or strategies);
- **Sharing** (collaborating as a risk-mitigation strategy, whether with suppliers, regulators, professional associations, or even competing firms).

Review and Revision

The review and revision segment of the COSO framework primarily pertains to additional **oversight and adjustments to the ERM framework**. This aspect of ERM begins with **re-evaluating risks** in light of any significant changes to a firm's business context. More importantly, it involves **being self-critical and responsive regarding the effectiveness of ERM processes** themselves. Ideally, any significant changes in the external environment should be promptly flagged and prompt modified ERM responses.

Communication, Reporting, and Disclosure

Communicating with stakeholders, both internal and external, is regarded as a vital component of successful Enterprise Risk Management (ERM). **Public disclosure** of risk management best practices can have a systemic effect, assisting even rival firms and entire sectors in transitioning towards a climate-ready and zero-emissions future. This is the foundation of the entire **Task Force on Climate-related Financial Disclosures (TCFD) framework.**

Operational risks possess limited potential for systemic impact on financial stability. However, there are critical climate risk transmission channels: Physical risk results in damage and business interruption, increasing operational and credit risk. Transition risk leads to asset stranding,

deteriorating companies' balance sheets and raising the probability of default and credit risk. Physical risk causes specific vulnerable geographies to be highly exposed, necessitating higher insurance premiums or even becoming uninsurable. Scope 3 greenhouse gas emissions for a company include upstream (supply chain) and downstream (product) emissions, excluding energy consumption.

Some primary limitations of physical climate risk scores are: Physical risk scores encompass multiple hazards, but the methods used to calculate and combine them remain a "black box" for investors. The normalization of raw data implies that physical risk scores are relative, not absolute.

Financial institutions are increasingly responsible for being the first to assess climate risk in transactions. Transaction decision-makers, such as portfolio managers or relationship managers, play a crucial role in this evaluation process.

BULLET POINTS:

- Measuring and defining climate risk is crucial for effective management, especially compared to other risks.
- **Climate risk** can impact multiple types of company-level risks such as **operational, credit, liquidity, and underwriting risks**. It can also pose a systemic risk that threatens financial stability and entire sectors of the economy.
- Corporate greenhouse gas emissions are categorized into three scopes: Scope 1 (direct emissions), Scope 2 (emissions from energy inputted), and Scope 3 (indirect emissions from supply chains and products).
- **Transition risks** require data beyond current emissions, such as emission trajectories and drivers, such as policy changes, technological advancements, consumer preferences, and market sentiment.
- **Physical risks** can be analyzed at the asset level, but it's more difficult. Alternatively, company-level scores can be used for simplicity, but these scores can sometimes lack transparency or cross-comparability between providers.
- Climate risk can be integrated into all facets of enterprise risk management, including risk governance, strategy, risk assessment, review, and disclosure.

PRACTICE QUESTIONS:

1. What is risk management?

   A. A structured approach to reducing the impacts of uncertain occurrences.
   B. A method for monitoring the weather.
   C. A tool for managing financial portfolios.
   D. A system for measuring climate change.

2. What is credit risk?

   A. The ability of a borrower to pay back a loan
   B. The interest rate of a loan
   C. The amount of a loan
   D. The duration of a loan

3. What is a potential consequence of inadequate staff training or management attention towards physical and transition climate effects?

   A) Increased productivity and acuity
   B) Improved internal processes
   C) Losses for the institution
   D) Increased reputation

4. What is the problem with climate risk, especially some types of physical climate risk?

   A. The risks are so concentrated that the risk of underwriting affected facilities and properties in those areas can grow too high to be economical
   B. The risks are not concentrated enough
   C. The risks are not affected by climate change
   D. The risks are affected by natural disasters

5. What is required to understand the application of multiple types of data to a user's needs?

   A. Topographical data
   B. Locational data of assets
   C. Appropriate analytical tools
   D. Historical data and climate models

6. What is the main focus of portfolio-level analysis when it comes to transition risks?

   A. Total absolute emissions
   B. Proportional amount invested or corporate revenues
   C. Impacts of risks on a particular firm
   D. Stress testing of the portfolio

7. What is the role of senior leadership in reflecting climate change and sustainability in a company’s culture?

   A. To enforce employee behavior
   B. To set expectations on climate
   C. To implement climate risk management strategies

D. All of the above

8. What is considered an integral part of successful ERM?

A. Communication
B. Reporting
C. Disclosure
D. All of the above

9. What is the purpose of Infosys' monitoring system?

A. To monitor water tables in each geographic area
B. To monitor the availability and cost of water for delivery via water tankers
C. To monitor the storage capacity of rainwater on each office campus
D. All of the above

10. What is transition risk analysis?

A. The analysis of emissions and emissions trajectories
B. The analysis of current emissions and future plans to reduce emissions
C. The analysis of corporate alignment with national and international goals
D. The analysis of drivers of transition risk

11. What is the potential impact of policy, operational, and technological changes on the fossil-fuel industry?

A. Increased revenue
B. Increased litigation
C. Decreased operational risk
D. Decreased credit risk

12. How are credit ratings agencies responding to the rise of credit risk due to climate risk?

A) They are ignoring the issue.
B) They are revising their outlook on the industry.
C) They are downgrading the creditworthiness of firms.
D) They are increasing the credit risk of firms.

13. What is one of the three categories of operational risk that is particularly important when analyzing climate risk?

A) Legal risk
B) External risk
C) People risk
D) Strategic risk

14. What is underwriting risk?

A. A type of risk that only affects the insurance sector
B. A type of risk that only affects corporations and financial institutions
C. A type of risk that affects only individuals
D. A type of risk that has no effect on any sector

15. What is the effect of operational risk on the economy?
A) It only affects individual companies
B) It has ripple effects across supply chains and through to markets, customers, and financial counterparties
C) It only affects the financial sector
D) It only affects the oil & gas sector

CHAPTER 7

Climate Models And Scenario Analysis

Climate models and scenario analysis serve as valuable instruments for non-financial corporations and financial institutions in addressing climate change challenges, encompassing risks associated with the physical consequences of climate change (physical risks) and the transition to a zero-carbon economy (transition risks). **Scenario analysis** involves devising and outlining potential future events through the creation of credible narrative scenarios. The concept, which traces its origins back to the 1950s, is often attributed to American researcher Herman Kahn.

Climate scenario analysis entails utilizing climate scenarios for analysis and decision-making purposes. It aims to strengthen corporate readiness for physical and transition-related climate impacts, communicate this preparedness to investors and other stakeholders, and guide strategy and investment decisions across diverse firms.

The TCFD encourages the use of scenario analysis to "boost critical strategic thinking" and question traditional assumptions about the future by employing plausible, distinct, coherent, pertinent, and challenging scenarios.

Merging scenarios can help address gaps in specific timeframes, sectors, or regions of interest. Scenario analysis for climate change differs substantially between the two primary types of climate risk: transition and physical risk.

For transition risk, non-financial corporations or financial institutions generally assess whether their facilities, strategies, and portfolios align with global projected emissions trajectories, or they examine the potential impacts of stricter climate policies (e.g., increased carbon tax) on their operations and plans.

For physical risk, incorporating emissions trajectories into a physical climate model enables the production of temperature rise, precipitation, extreme weather, and other phenomena estimates. However, due to global climate system lags, physical consequences of climate change are nearly identical for the next few decades (until around 2050) regardless of emissions. Consequently, for physical risk specifically, scenario analysis focuses more on utilizing the ongoing and anticipated physical climate impacts to enhance firms' preparedness and resilience. Emissions trajectories only influence physical risk on very long timescales, while they significantly impact transition risk even on short timescales.

For financial institutions, climate scenario analysis can be valuable for assessing portfolio alignment with the Paris Agreement's goals (well below a 2-degree increase), influencing or directing new investment decisions by portfolio managers, or offering a top-down "stress test" approach wherein a portfolio is evaluated under specific assumptions and conditions.

Stress tests, which model the response of both the entire financial system and individual institutions' balance sheets to hypothetical shocks, inherently depend on scenario analysis. Regulators widely adopted stress tests following the 2008 global financial crisis, and they are now progressively being repurposed to examine climate change risk.

Global Reference Scenarios

Net zero involves reducing global emissions ("sources") to zero in virtually all sectors of the global economy, and continually balancing residual emissions that cannot be removed with removals ("sinks"). To stabilize the climate at a specific temperature, such as the Paris Agreement's goal of limiting global average temperature increase to well below 2°C and striving to restrict temperature increases to 1.5°C, 2°C, 2.5°C, 3°C, or 4°C, we must achieve net-zero carbon emissions to stabilize atmospheric carbon levels.

RCPs were formulated by reverse-engineering the emissions that would result in a specific amount of radiative forcing—the difference between solar radiation (energy) absorbed by Earth and energy radiated back into space—that would then lead to a certain level of warming. Consequently, RCP names are based on the amount of radiative forcing measured in watts/meter squared (m2), **not degrees Celsius**. The most commonly used models are RCP 2.6 and RCP 8.5. RCP 2.6 is shorthand for achieving Paris goals (limiting warming to below 2°C) by drastically reducing emissions. RCP 8.5, which assumes rising emissions leading to significantly higher warming levels, is often referred to as "business as usual" and occasionally as a "worst-case scenario."

Originally, **RCPs did not include a socioeconomic "narrative," only emissions trajectories calculated using certain energy use assumptions**. In response, shared socioeconomic pathways (SSPs) were subsequently developed to be used in conjunction with RCPs. **SSPs aim** to provide **plausible scenarios for global evolution in areas such as population, economic growth, education, globalization level, urbanization level, and technological development rates.** The five SSP scenarios range from better to worse climate change outcomes, and their base scenarios deliberately exclude climate policies.

SSPs offer more flexibility for models and scenarios, as they allow various ways to achieve similar emissions outcomes. However, not all RCPs are achievable under all SSPs—for example, a high-mitigation scenario is not feasible under SSP3's "regional rivalry" assumptions. Integrated assessment models are the models that can evaluate the combination of social, economic, energy, emissions, and climate factors.

Among the most important scenarios are those developed by the **International Energy Agency (IEA).** The IEA's two core scenarios are

1) Stated Policies Scenario, reflecting existing policy frameworks and announced policy intentions;

2) the Sustainable Development Scenario (SDS), combining climate and social targets and limiting warming to 2°C in line with Paris targets. The IEA has also modeled net-zero emissions by 2050 scenarios and occasionally other scenarios, such as a delayed economic recovery scenario in 2020 in response to the global COVID-19 pandemic.

Source	Scenario Name	Description	Key Dates	
			Peak emissions	*Net-zero emissions*
IEA	Stated Policies Scenario (STEPS)	The Stated Policy Scenario reflects the impact of existing policy framework and announced policy intentions to show how current policy ambitions affect the energy sector through 2040.	2030	Not modelled beyond 2040
	Sustainable Development Scenario (SDS)	The Sustainable Development Scenario is fully aligned with Paris agreement goals, and it holds global temperature rise to below 1.8°C with a 665 probability and without relying on global-level net negative emissions.	2021	Not modelled beyond 2040
	Net-Zero Scenario [2021]	The Net-Zero scenario is aligned with fully net-zero emissions by 2050 across buildings, transport, industry, and power and heat.	2019	2050
IRENA	Planned Energy Scenario	A scenario based on governments' current energy plans and nationally determined contributions	2030	Not modelled beyond 2050
	1.5°C Scenario	A pathway aligned with net-zero emissions by 2050 and thus with maintaining warming below 1.5°C	2021	2050
Greenpeace	Advanced Energy [R]evolution	Pathway to a fully decarbonized energy system by 2050	2020	2050
Institute for Sustainable Development	Deep Decarbonization Pathways Initiative	Country-level pathways for emissions reductions that are consistent with a global 2°C goal	n/a	n/a
NGFS	Orderly Scenario	Climate policies are introduced early and gradually tightened, leading to a steady fall in all greenhouse gas emissions. Warming is likely to be limited to below 2°C.	2020	2060
	Disorderly Transition Scenario	Climate policies are introduced later and more abruptly from 2030. Emissions reductions are sharper, leading to higher transition risk.	2030	2050
	Hothouse Earth Scenario	Current policies are preserved, and Paris goals are not met. Emissions continue to grow until 2080, leading to more than 3°C of warming and significant physical risks.	2080	No net zero

Source: SCR Certificate (2023)

Scenario Parameters

The **usefulness and output** of global scenarios **vary for transition risk compared to physical risk.**

For transition risk, non-financial corporations or financial institutions typically assess if their facilities, strategies, and portfolios are in line with one of the projected global emissions trajectories. Alternatively, they pose the hypothetical question of what would happen if climate policies or other parameters were tightened.

For physical risk, emissions trajectories are significant to the extent that, when input into a physical climate model, it becomes possible to derive estimates of temperature increase, precipitation, extreme weather events, and other phenomena. However, due to the lag in the global climate system, different types of scenario analysis that do not utilize emissions trajectories can sometimes be more beneficial.

Scenario analysis begins with selecting a scenario and setting parameters. In many, if not most cases, starting with a reference scenario will be adequate, without needing to construct a bottom-up analysis of global energy use by sector from the ground up. All climate scenarios have a number of **built-in parameters or assumptions, ranging from macroeconomic variables (e.g., GDP growth) to energy demand and the energy mix to policies.**

Performing scenario analysis requires making analytical choices on scope and methods, including quantitative versus qualitative methods. Scope can also be influenced by data

availability, for example, relating to supply chains**. Climate scenario outputs** can vary from revenues or costs to asset valuations, such as from assets becoming stranded. The following table, adapted from the TCFD Technical Supplement, emphasizes key choices to be made.

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Parameters/Assumptions	Analytical Choices	Scenario Outputs
• **Discount rates** • **Carbon Price** • **Energy demand and mix** • **Commodity prices** • **Macroeconomic variables**—for example, GDP, employment • **Geographic variation** • **Demographics and employment** • **Technology** • **Policy** • **Climate system sensitivity**—such as the response of climate to given amount of CO_2	• **Quantitative vs qualitative methods** • **Timescale**—2030, 2050, 2100 [2100 only relevant for long-term infrastructure] • **Scope of analysis** • **Data availability** • **Choice of climate hazards**—for example, heat, floods, extreme weather • **Extent of supply chain inclusion** • **Balance of economic, social, and physical analysis**	• **Earnings/profits** • **Revenues** • **Costs** • **Asset valuations**—how badly are assets stranded? • **Investment/capital expenditure** • **Asset allocation** • **Potential impact on productivity** • **Business interruption from physical hazards**
		Source: TCFD Technical Supplement.

Source: SCR Certificate (2023)

Scenario Analysis for Transition Risk

Transition risk scenario analysis is closely and directly connected to emissions scenarios, including RCPs, IEA scenarios, or custom-made emissions scenarios. This is because transition risk directly results from the speed, pace, and scale of the low-carbon transition. **Transition risk increases when emissions are cut more drastically** (such as in a net-zero emissions by 2050 scenario compared to a current policies or business-as-usual scenario) and when emissions cuts are more sudden (disorderly versus orderly transition). Usually, **transition risk analysis** for a corporation or financial institution involves assessing whether its **operations, supply chains, and portfolios align with sector-specific and/or global, macroeconomic emissions trajectories.**

On a broad, global scale, economic models that incorporate climate change and climate policy can be useful. Integrated assessment models (IAMs) are comprehensive models designed to analyze how societal and economic choices affect each other and the natural world, including the causes of climate change. Widely used by the IPCC, they are also frequently employed by academics, and occasionally by policymakers and corporations. The most basic IAMs compare the costs and benefits of avoiding a certain level of warming using highly simplified equations and can answer both general and specific questions.

For most sectors or firms exposed to multiple sectors (such as banks or institutional investors), sector **decarbonization pathways are an effective way to measure transition risk.** Many such pathways exist, including those developed by the IEA, the Deep Decarbonization Pathways Project, the Transition Pathway Initiative, Mission Possible Partnership (MPP), or the Science-Based Targets Initiative. These decarbonization pathways are designed to be compatible with Paris targets.

External bodies also assess alignment with various scenarios (for example, the Transition Pathway Initiative, a collaboration between academia and industry, grades publicly listed companies based on their alignment with Paris-compliant sector trajectories). Commercial data providers such as **Carbon Delta, Carbone 4, Oliver Wyman, WTW, Ortec Finance, NGOs** like the 2 Degrees Investing

Initiative, and consortiums like Climatewise (part of the Cambridge Institute for Sustainability Leadership) also conduct a considerable amount of transition risk scenario analysis. Most of these entities provide detailed data on different asset classes by scenario (RCP) and time horizon, enabling firms to conduct in-house analysis.

Lastly, a more ambitious approach to transition risk scenario analysis involves **constructing entirely original emissions trajectories.** Building bottom-up global models of energy demand and emissions, similar to the IPCC or IEA pathways, usually only makes sense for large fossil fuel and commodity firms whose fortunes are closely linked to global changes in the energy mix.

Scenario Analysis for Physical Risk

Scenario analysis for physical risks significantly differs in its approach. One distinction is that physical climate models are necessary **to translate emissions trajectories into physical impacts**. **Another crucial difference is that the climate system's delayed response** means that physical impacts until around 2050 are primarily determined by current emissions, rendering emissions trajectories irrelevant for the next few decades— a timeframe most policymakers, firms, and investors focus on. Consequently, a distinct type of scenario analysis—focused on operational preparedness based on plausible future events rather than global or sector emissions trajectories—may be more useful for assessing physical risk.

Climate models and emissions scenarios share a reciprocal relationship, with models helping to modify emissions scenarios to reach specific temperature targets and scenarios informing models to forecast potential hazards. Unlike transition risk, **physical risk assessment always starts at the facility level,** affecting both non-financial and financial firms as an operational risk. Industrial firms can contrast their facilities with sector benchmarks for transition risk, while financial firms can employ emissions data for key emissions-intensive sectors. Nonetheless, physical risk impacts all sectors and assets.

Investigating **facility-level physical risk necessitates detailed data on hazards, exposure, vulnerability, and adaptive capacity. Physical risk scenario analysis generally focuses more on operational aspects in the short term (up to 2050) due to the lower relevance of emissions scenarios for physical risk and the risk's inherent nature.** Physical climate models can help pinpoint areas susceptible to physical impacts but lack the precision to forecast acute physical hazards. Using these models, plausible scenarios can be developed to facilitate preparedness for impacts. Developing historically plausible scenarios of anticipated climate change hazards can equip us to confront acute physical threats.

Scenario Analysis in Corporate World

A crucial reason for companies to engage in scenario analysis is to establish corporate strategy and communicate that strategy to investors and other stakeholders. If organizations do not develop climate change plans and conduct analyses perceived as credible and comprehensive, investors may hold companies accountable.

Another vital reason why scenario analysis is important for businesses is self-interest, as it can help identify opportunities and anticipate future demand for products. Conducting scenario analysis is also essential for firms to reduce operational risk and enhance preparedness and resilience. A company can outline scenarios where its critical operational or supply chain assets are impacted by

transition or physical risk-related shocks (e.g., a sudden large carbon tax increase, or a massive storm) and then evaluate how significantly this would affect the business.

These scenarios can be based on plausible but unrealized events or recent actual events, and they apply to both financial and non-financial firms since all types of companies utilize physical facilities and depend on a network of suppliers and customers. This type of scenario analysis is particularly effective in addressing the potential for business disruption. Climate-linked business disruption related to physical climate risk is not a distant future prospect but is already happening.

Scenario analysis usage in the financial sector aims to investigate portfolio-level exposures and measure how these would differ in various climate outcomes (i.e., scenarios). Stress testing, a practice widely used by financial regulators for over a decade, has now been adopted by both public and private sectors. Ex-ante financial analysis employs forecasting or predictions for future events.

Incorporating scenario analysis into the toolkit of portfolio managers and other investment decision-makers can potentially prevent excessive exposure to climate risk or serve as an early indication of where investment firms can concentrate engagement efforts. Scenario analysis can be valuable for finance and investment purposes in multiple ways, such as assessing potential risks and opportunities associated with different economic, market, and regulatory scenarios. It can also inform strategic planning, stress testing, and capital allocation decisions. Furthermore, scenario analysis can help evaluate the impact of climate change and other ESG (environmental, social, and governance) factors on financial performance and investment portfolios.

BULLET POINTS:

- Scenario analysis is a method of using stories to depict potential future states of the world, which was first used by large corporations in the 1950s and is now widely used to analyze climate risk.
- Global reference scenarios are widely accepted projections of future emissions that often come with socio-economic narratives, and are essential for climate scenario analysis.
- The most commonly used reference scenarios are created by the IPCC, which include representative concentration pathways (RCPs) and shared socio-economic pathways (SSPs) that can include societal and economic nuances and policy changes.
- Other significant providers of reference scenarios include the IEA, Greenpeace, IRENA, and NGFS.
- Despite starting with these reference scenarios, scenario analysis requires several decisions to be made, including setting parameters/assumptions, selecting analytical tools, and determining outputs.
- Integrated assessment models (IAMs) can be used for transition risk scenario analysis, which are economic models that include representations of societal and environmental phenomena and sector-specific decarbonization pathways.
- Physical risk scenario analysis utilizes physical climate models, along with resilience planning, to prepare for potential physical impacts of climate change.
- Corporations, financial and non-financial alike, use scenario analysis for strategy and communication with stakeholders such as investors and regulators, as well as for resilience planning.
- Financial institutions also use scenario analysis for portfolio risk management, stress testing, and portfolio selection.

PRACTICE QUESTIONS:

1. What is the purpose of climate scenario analysis?

   A) To predict the future accurately
   B) To ensure a firm-wide approach to preparedness
   C) To enhance critical strategic thinking and challenge conventional wisdom
   D) To communicate preparedness to stakeholders

2. What are the most widely used reference scenarios for climate change?

   A) Scenarios created directly by the Intergovernmental Panel on Climate Change (IPCC)
   B) Scenarios from the International Energy Agency
   C) Scenarios from various non-profit and academic sources
   D) All of the above

3. What is scenario analysis used for by non-financial firms?
   A) Corporate disclosure.
   B) Capital expenditure investment decisions.
   C) High-level strategy setting.
   D) Both B and C.

4. Why is it necessary to achieve net-zero carbon emissions to stabilize the climate?

   A. To stabilize the climate at any given temperature
   B. To stabilize the stock of carbon in the atmosphere
   C. Both A and B
   D. None of the above

5. How is the IEA's World Energy Outlook considered?

   A) The most comprehensive and innovative analysis of the energy sector
   B) The most recent and up-to-date assessment of the energy sector
   C) The most definitive global assessment of the energy sector
   D) The most advanced and groundbreaking analysis of the energy sector

6. What kind of organizations typically examine transition risk?

   A) Financial institutions
   B) Non-financial corporations
   C) Government agencies
   D) Environmental organizations

7. What is the first step in scenario analysis?

   A. Deciding the scope
   B. Building a bottom-up analysis
   C. Choosing a scenario
   D. Evaluating the macroeconomic variables

8. What is transition risk scenario analysis tied to?

A. Emissions scenarios
B. Supply chains
C. Societal and economic choices
D. Physical processes

9. What do the SSP scenarios range from?
A. Better to worse climate policy options
B. Better to worse emissions trajectories
C. Better to worse socioeconomic outcomes
D. Better to worse projections from various organizations

10. What has been the largest discrepancy in the IEA's forecasts on renewable energy uptake?

A) The amount of wind capacity added annually
B) The amount of hydro capacity added annually
C) The amount of nuclear capacity added annually
D) The amount of solar photovoltaic capacity added annually

11. What are some common parameters that must be decided on before starting a scenario analysis?

A) The type of climate risk being analyzed
B) The use of emissions trajectories
C) The time lag in the global climate system
D) All of the above

12. What are some of the outputs of climate scenario analysis?

A. The energy mix
B. Revenues or costs
C. Physical risk
D. Asset valuations

13. What is the difference between quantitative and qualitative methods in scenario analysis?
A. Qualitative methods are more data-driven
B. Quantitative methods are more subjective
C. Quantitative methods are more analytical
D. Qualitative methods are more visual

14. What kind of models can be used to analyze the effects of societal and economic choices on the natural world, including the causes of climate change?
a) Physical models
b) Political models
c) Economic models
d) Integrated Assessment Models (IAMs)

15. What is the difference between top-down and bottom-up approaches to transition risk scenario analysis?

A) Top-down works forwards from where the sector is today, while bottom-up works backwards from net zero globally.
B) Top-down focuses on commercially feasible, scalable action, while bottom-up considers interlinkages across sectors and structural shift.

C) Bottom-up works forwards from where the sector is today, while top-down works backwards from net zero globally.
D) Bottom-up focuses on commercially feasible, scalable action, while top-down considers interlinkages across sectors and structural shift.

CHAPTER 8

Net Zero

The concept of **net-zero emissions** emerged from scientific discussions on the link between anthropogenic emissions and global temperature changes. A linear relationship exists between **cumulative net emissions of greenhouse gases and changes in global surface temperatures**, which implies that halting anthropogenic climate change requires a balance between greenhouse gases entering the atmosphere and those removed via sinks.

Stabilizing global temperatures at any level requires global greenhouse gas emissions to reach net zero, meaning all emissions are balanced by corresponding removals. **The Paris Agreement** established a common aspiration **to limit global warming to well below 2°C above pre-industrial levels and pursue efforts to limit the increase to 1.5°C.**

The Special Report on the impacts of global warming of 1.5°C highlighted the substantial effects of an extra 0.5°C of warming and provided evidence for the challenge of reaching the 1.5°C target. While the 1.5°C target has become the standard for assessing climate ambitions, reaching it requires a sharp reversal in emission trends, with global net emissions needing to peak before 2025, decline by 43% by the 2030s, and reach net zero in the early 2050s.

The 2018 report and subsequent analyses by **the IPCC** sharply underline that reaching the 1.5°C target is a major challenge that requires a sharp reversal in emission trends. In its most recent report, the IPCC estimates that to limit global warming to 1.5°C, global net emissions would need to peak before 2025, decline by 43% by the 2030s, and reach net zero in the early 2050s (IPCC, 2022).

The difference between a global temperature rise of 1.5°C and 2°C can have significant implications for the environment and human societies. According to the 2018 IPCC Special Report on 1.5°C, a 0.5°C increase in warming would lead to a rise in severe heat exposure for 37% of the global population, compared to 14% under a 1.5°C scenario. Additionally, while 1.5°C of warming would still result in a 70-90% reduction in average coral cover, it would prevent the total loss of coral reefs projected with 2°C of warming. The probability of extreme drought and water stress, particularly in the Mediterranean region and southern Africa, is substantially higher under a 2°C scenario compared with a 1.5°C scenario. Finally, an additional 10 million people are estimated to be at risk of flooding under a 2°C scenario, compared to a scenario where warming is limited to 1.5°C by 2100.

The 2022 IPCC Report on Impacts, Adaptation and Vulnerability reiterated many of these findings, highlighting that a 1.5°C temperature rise would cause unavoidable increases in various climate hazards and present multiple risks to humans and ecosystems. The report also stresses that limiting global warming to 1.5°C would significantly reduce projected loss and damages compared to higher warming scenarios.

The global goal of achieving net-zero carbon emissions by 2050 has gained traction among governments and non-state actors worldwide**. As of November 2021, 135 countries, representing 88% of global emissions and 90% of global GDP, had committed to net-zero targets, while 7,500 entities had joined the UN Race to Zero campaign.** However, the commitment levels vary significantly across entities and countries, with different targets, scopes, and degrees of legal commitment. Some entities have well-defined implementation plans with clear strategies and interim targets, while others have made vague public statements. To distinguish between credible and non-credible commitments, there is a need for developing tools and frameworks that can effectively navigate the transition towards net-zero emissions.

KEY ALLIANCES IN THE RACE TO ZERO		
Name	**Actors**	**Description**
PUBLIC SECTOR ALLIANCES		
Cities Race to Zero	Cities	Coalition of cities that have publicly joined the Race to Zero and committed to achieving net-zero emissions by 2050.
Under 2° Coalition	**Under 2° Coalition**	Coalition of sub-national governments committed to reaching net zero by 2050 or earlier.
FINANCIAL SECTOR ALLIANCES		
Glasgow Financial Alliance for Net Zero (GFANZ)	Financial sector	An umbrella group of various finance subsector alliances that are part of Race to Zero, with more than 450 member firms from across the global financial sector.
UN Environment Programme Finance Initiative (UNEP FI)	Financial sector	Initiative that works with over 400 financial-sector institutions (including banks, insurers, investors) with the goal of ensuring that financial systems support both people and planet.
Commercial banks		
Net Zero Banking Alliance (member of GFANZ)	Banks	An alliance of global banks that have committed to reaching net zero by 2050.
REAL ECONOMY (NON-SECTOR SPECIFIC)		
Business ambition for 1.5°C	Corporates	A collaboration by the Science-Based Targets Initiative, the UN Global Compact, and the We Mean Business Coalition, which seeks to encourage private businesses to develop science-based emissions-reduction targets in line with the 1.5°C target.
The Climate Pledge	Corporates	A campaign co-founded by Global Optimism and Amazon which seeks to call businesses and other organizations to action on climate. Its signatories have pledged to reach net zero by 2040.
Certified B Corporation	Corporates	B Lab is both a non-profit network and certification scheme. It certifies companies, known as B-Corps, who adhere to particularly high standards regarding their social and environmental impact, transparency, and accountability.
SME Climate Hub	Small and medium-sized companies	A hub that provides the tools, resources, and frameworks that allow businesses with fewer than 500 employees to commit to reaching net zero by 2050 or sooner.
Business Declares	Corporates	Non-profit organization that seeks to raise awareness for climate emergency in the private sector, accelerate private-sector action, and amplify the voices in the business community that are calling for regulatory action.

Name	Actors	Description
CBN Expert Community	Corporates	Community of organizations that have pledged to achieve net-zero emissions via CBN Expert, a firm that supports companies seeking to calculate, measure, and track their carbon footprint.
Planet Mark	Corporates	Sustainability certification scheme through which organizations can certify their net-zero pledge.
REAL ECONOMY (SECTOR SPECIFIC)		
Tech Zero	Tech sector	Collection of technology companies that have committed to measure and disclose Scope 1, 2, and 3 emissions and set ambitious net-zero targets.
Pledge to Net Zero	Environmental sector	A pledge through which organizations from the environmental sector are committing to reduce their own emissions in line with at least a 2°C target, and actively contribute to the conversations on how targets can be achieved (e.g., by publishing thought pieces).
Race to Zero for Universities & Colleges	Higher education	Collaboration by UNEP, the alliance for sustainability leadership in education (EAUC), and second nature, which are mobilizing universities and colleges to commit to Paris-align their operations.
Fashion Industry for Climate Action	Fashion industry	Pledge by stakeholders in the fashion industry to reduce emissions by at least 30% before 2030 and reach net zero by 2050.
Healthcare Without Harm	Healthcare sector	Alliance that focuses on mobilizing the healthcare industry to move toward a net-zero future.

Name	Actors	Description
Asset managers		
Net Zero Asset Managers Initiative (member of GFANZ)	Asset managers	An initiative designed to mobilize climate ambition among international asset managers. All members have committed to reaching net zero by 2050 and are using the forum to develop and share best-practices.
Asset owners		
Paris Aligned Investment Initiative (member of GFANZ)	Asset owners	A collaborative, investor-led forum of 118 institutional investors that are seeking to align their operations with the goals of the Paris Agreement.
Net Zero Asset Owner Alliance (member of GFANZ)	Asset owners	A coalition of 71 pension funds and insurers that are collaborating to Paris-align their investment activities.
Insurers		
Net Zero Insurance Alliance (member of GFANZ)	Insurers	A group of 20 leading insurers that have committed to aligning their insuring and reinsurance underwriting portfolio with the 1.5°C target enshrined in the Paris Agreement.
Other financial services		
Net Zero Financial Service Provider Alliance (member of GFANZ)	Financial service providers	An alliance of investment advisors, auditors, rating agencies, index providers, ESG research and data providers, and exchanges. All members have committed to achieving net-zero greenhouse gas emissions by 2050 or sooner.
Net Zero Investment Consultants Initiatives (member of GFANZ)	Investment consultants	A coalition that sets actions that investment consultants will take in the context of their legal and fiduciary duties, as well as specific client mandates, to support reaching the global net-zero target by 2050 or sooner.

REAL ECONOMY (NON-SECTOR SPECIFIC)		
Business ambition for 1.5°C	Corporates	A collaboration by the Science-Based Targets Initiative, the UN Global Compact, and the We Mean Business Coalition, which seeks to encourage private businesses to develop science-based emissions-reduction targets in line with the 1.5°C target.
The Climate Pledge	Corporates	A campaign co-founded by Global Optimism and Amazon which seeks to call businesses and other organizations to action on climate. Its signatories have pledged to reach net zero by 2040.
Certified B Corporation	Corporates	B Lab is both a non-profit network and certification scheme. It certifies companies, known as B-Corps, who adhere to particularly high standards regarding their social and environmental impact, transparency, and accountability.
SME Climate Hub	Small and medium-sized companies	A hub that provides the tools, resources, and frameworks that allow businesses with fewer than 500 employees to commit to reaching net zero by 2050 or sooner.
Business Declares	Corporates	Non-profit organization that seeks to raise awareness for climate emergency in the private sector, accelerate private-sector action, and amplify the voices in the business community that are calling for regulatory action.

Source: SCR Certificate (2023)

The Implications of Net Zero

Country level:

The emission accounting **standards for countries** typically use a territorial or production-based method, which means that a country's emissions are based on the emissions that occur within its geographic borders. **To achieve a net-zero target, a country must significantly reduce its greenhouse gas emissions and remove any remaining emissions through carbon sinks.** However, this approach has been criticized for not considering the consumption patterns that drive emission-intensive production elsewhere. **An alternative approach is to use consumption-based accounting methods**, which measure the cumulative emissions resulting from the production of goods and services consumed within a country, regardless of where the production took place. **High-income countries usually have higher consumption-based emissions than production-based emissions,** while **low- and middle-income countries often have emissions-intensive industries catering to foreign demand.** Despite concerns, production-based accounting is the dominant standard for attributing emissions at the country level. Achieving net-zero at the national level requires a system-level understanding of the economy and energy system, and policy decisions will depend on various factors, including economic and technological means, voter preferences, and political will.

Sub-national governments:

Sub-national climate policies are becoming increasingly important, but there is currently no universally accepted standard for measuring emissions at the sub-national level. Therefore, cities and regions face a challenge in creating greenhouse gas inventories, determining baseline emissions, and defining their targets. The GHG Protocol's Protocol for Community-Scale Greenhouse Gas Emissions Inventories is a widely recognized best practice standard that distinguishes between Scope 1, 2, and 3 emissions. **The GHG Protocol has developed two reporting standards, BASIC and BASIC+, for cities and regions based on this distinction. BASIC** inventories cover scope 1 and 2 emissions from energy and transport, as well as scope 1 and 3 emissions from waste. **BASIC+** inventories are more comprehensive and cover scope 3 emissions from transboundary transport and scope 1 emissions from

agriculture, forestry, and land use. The emissions inventories define the target for reaching "net zero," so it is important for cities and regions to use consistent standards. Generally, cities and regions must decarbonize urban transport systems and reduce emissions from buildings to achieve their targets.

Private Sector:

Non-Financial Sectors:

The impact of the net-zero transition on firms in the real economy varies depending on the sector. **Energy-intensive industries** with high Scope 1 emissions will need to develop alternatives to current production processes through technological innovation and deploying less emissions-intensive solutions at scale. **High-emitting sectors** may require increased investment to decarbonize and retire high-emitting assets early. For example, steel producers need to find energy carriers to replace fossil fuels for producing steel. Other sectors, like many supermarket chains, have small Scope 1 emissions compared to emissions across the value chain of their products. In these sectors, the challenge is to understand Scope 3 emissions embedded in products and work with partners across the value chain to minimize these, as well as customers' and consumers' use and disposal of products.

Financial Sectors:

The net-zero transition presents unique challenges for the financial sector, as the climate impact of financial institutions mainly **comes from the activities they finance rather than their own operations**. While there is little regulation in this area, industry-led alliances and voluntary standards have emerged to help financial institutions establish the climate impact of their portfolios and develop strategies for reducing their financed emissions over time. Financial services use different tools and methodologies, such **as implied temperature ratings and sectoral pathways, to support their net-zero strategies and targets**, but it is important to understand their assumptions, models, and limitations when using them.

Transition Plans:

Transition plans are becoming increasingly important in the private sector as a way to implement climate action and demonstrate the credibility of commitments. These plans are defined as time-bound strategies that outline how an organization will shift their assets, operations, and business model to align with the latest climate science recommendations, ultimately reaching a net-zero-carbon economy. Although this concept is relatively new, the **TCFD** has released high-level guidance outlining the necessary components for effective transition plans. These plans should align with overall **corporate strategy, have measurable targets, be subject to effective governance, be full of actionable initiatives, be credible, reviewed and updated regularly, and reported annually to stakeholders.** The content of the plans should reflect how the organization will adapt its **governance structure and strategy** to deliver the transition, manage and mitigate transition risks, and what **metrics and targets** will monitor and track progress.

Following **COP26, the UN Race to Zero** campaign has shifted from simply encouraging entities to commit to net-zero targets to developing more rigorous standards and supporting members in implementing their targets. The UN Secretary General has announced that a High-Level Expert Group will be established in 2022 to propose standards for assessing targets published by non-state actors. Climate initiatives have also developed overarching or sector-specific benchmarks to assess the

ambition behind individual pledges. Fankhauser et al. (2022) have summarized the debate and identified seven attributes that net-zero targets should fulfill to provide a meaningful framework for action. These include **front-loaded emission reductions (***to meet Paris Agreement targets, entities must reduce emissions as soon as possible, as global temperature change is determined by cumulative emissions, not just emissions in any given year***)**, **a comprehensive approach to emission reductions (***reaching net-zero requires tackling all emissions, including hard-to-abate sectors. Governments and private corporations should reduce emissions across all scopes and engage with all stakeholders along the value chain***), cautious use of carbon dioxide removal (***prioritize deep emissions reductions as there are unresolved issues with most forms of carbon dioxide removal***), effective regulation of carbon offsets (***mechanisms to balance global sources and sinks should meaningfully address concerns and allow for monitoring, reporting, and verification of removed carbon***), an equitable transition to net-zero (***recognize that developing countries will need more time, financial and technological support to transition, and that certain actors will need to decarbonize at different speeds***), alignment with broader socio-ecological objectives (***a narrow focus on mitigation may overlook negative repercussions in other dimensions, such as economic inequality or the marginalization of indigenous communities***), and pursuit of economic opportunities (***effective net-zero planning should consider economic opportunities arising from the transition***).** Transition plans offer organizations the chance to demonstrate how their net-zero targets align with these attributes and benefit local populations.

The Science-Based Targets initiative (SBTi) has developed a framework to provide guidance on how financial firms can set science-based, Paris-aligned net-zero targets. The SBTi recommends three different approaches, including **setting physical intensity targets for investments and loans in emission-intensive sectors, working to ensure increasing proportions of investees in portfolios have committed to their own respective science-based targets, and aligning portfolios with long-term temperature targets by engaging with portfolio companies.** The SBTi also emphasizes the importance of engaging with investees and financing their transition to achieve effective emission reductions, while adjusting portfolio holdings and divesting from companies with low ambition are complementary strategies.

Carbon offsetting involves balancing greenhouse gas emissions by sequestering carbon or other gases elsewhere, but there are challenges in determining what activities should be eligible and ensuring social and environmental integrity. While carbon markets allow entities to balance emissions with carbon credits, there are concerns about non-additional projects, leakage, permanence, and accurate measurement. Certification bodies have developed standards, but these are not universally applied, and organizations must carefully tread when relying on offsets to reach decarbonization targets. The Oxford Principles for Net Zero Aligned Carbon Offsetting and the Science-Based Targets initiative stress the need to prioritize deep emissions reductions and shift to high-quality, long-lived carbon removal offsetting while being cautious about using carbon credits to measure progress on net-zero targets.

Interim Targets and Pathways Detailed

The key to achieving credible and attainable net-zero targets is through detailed net-zero pathways and interim targets. For countries, **Climate Action Tracker** has identified ten key elements of national net-zero target setting, including comprehensive planning, stakeholder management, review processes, and transparency. Comprehensive emission reduction pathways with adequate interim targets are essential for governments to limit global warming to 1.5° or 2°C above pre-industrial averages, as yearly emissions alone are insufficient. While some countries have recently updated their

Nationally Determined Contributions to reflect more ambitious interim targets, no country currently has a credible and attainable pathway to reach net-zero emissions by 2050.

Similarly, it is crucial for private sector targets to be credible. While around a fifth of companies on the Forbes Global 2,000 list have committed to net zero, less than 16% have set interim targets. To address this, sectoral transition pathways are being developed by organizations such as industry tracker and the transition pathway initiative to provide coherent data on transition pathways of companies to asset managers and owners. Companies should take advantage of industry-specific benchmarks, consider local net-zero policies, determine specific short- and medium-term interim targets, and consult with key stakeholders. Initiatives like Science Based Targets can help verify that targets are science-based and realistic.

Metrics To Track Progress Towards Net Zero Net Zero

Cross-industry principles & metrics

The Task Force on Climate-related Financial Disclosures (TCFD) recommends that organizations disclose climate-related metrics to cover three main topics: **disclosing metrics used to assess climate-related risks and opportunities, Scopes 1 and 2 emissions, and targets used to manage climate-related risks and opportunities.**

Organizations should also disclose **metrics used to assess progress against their decarbonization targets, including operational and financial performance metrics, cross-industry climate-related metric categories, and industry-specific or organization-specific metrics. Historical data** should be provided to allow for trend analysis, and the metrics should be closely related to the targets set. Organizations should define metrics that appropriately cover the topics defined above and harvest low-hanging fruits while defining processes to automate and standardize the calculation of more complex quantitative measures. The usage of carbon-related metrics can go beyond reporting, and they can be used for project selection purposes and internal carbon pricing to account for emissions in net present value calculations.

Metrics for financial institutions

Financial institutions have access to various tools that help them assess whether their investments align with sustainability goals. **ESG ratings and data** are commonly used, but **they lack the depth needed to determine whether a company is on a net-zero by 2050 path or how it compares to benchmark schedules. Portfolio alignment tools** are needed to answer these questions. **The Portfolio Alignment Team** identifies three broad groups of portfolio alignment tools, each based on a core question: **binary measurement, benchmark divergence, and implied temperature rise (ITR).** However, the quality of reporting using these tools depends on the scientific robustness of the specifications and choices made in the modeling of the scores. For instance, when using binary measurement, asset managers need to determine what is classified as a net-zero target.

Each of the three portfolio alignment tools has its own strengths and weaknesses. **Binary measurement** is easy to use, applicable to any asset class and provides a simple way to check if an entity reports a net-zero target. However, it lacks insight into the degree of net-zero alignment and can be challenging to aggregate results to the portfolio level. **Benchmark divergence** generates a measurement of the degree of alignment/misalignment, allows progress evaluation towards net zero, and can be aggregated to the portfolio level. However, it is complex and requires climate-scenario

expertise, as well as potentially difficult-to-obtain data such as company-level emissions projections and benchmarks. On the other hand, **implied temperature rise (ITR)** has all the benefits of benchmark divergence, plus it measures the consequence of alignment/misalignment and provides easily understood output. However, it is also complex, requires climate-scenario expertise, and may be based on potentially difficult-to-obtain data.

Financial institutions can also use **portfolio alignment tools to set sector-specific targets and assess whether industry-specific sub-portfolios align with net-zero pathways.** They should focus on **decarbonizing sectors with the most impact, including Scope 3 emissions**. **Taxonomies, such as the EU Sustainable Finance Taxonomy**, can help categorize investments based on their contributions to high emissions or decarbonizing activities. While taxonomies provide less detail than portfolio alignment tools, they are simple to use, understand, and increasingly included in regulatory frameworks. The UK Climate Financial Risk Forum provides an exemplary taxonomy for fossil fuel producers.

Cross-Industry, Climate-Related Metrics Categories, and Example Metrics	
Metric category	**Example metrics**
GHG emissions	• Absolute Scope 1, 2, and 3 emissions • Financed emissions by asset class • Emissions per MWh of electricity produced
Transition risks	• Concentration of credit-exposure to carbon-related assets • Percent of revenue from coal mining
Physical risks	• Proportion of real assets exposed to 1:200 climate-related hazards • Revenue associated with water withdrawn and consumed in regions with high baseline water stress
Climate-related opportunities	• Number of zero-emission vehicles and hybrid vehicles sold • Revenues from products or services that support the transition to a low-carbon economy
Capital deployment	• Percentage of revenue invested in R&D of low-carbon products • Investment in climate adaptation measures (e.g., flood defenses, location changes)
Internal carbon prices	• Internal carbon price (e.g., a company internal tax on emissions that is invested into sustainability projects) • Shadow carbon price (an estimated cost of carbon used for project selection purposes)
Remuneration	• Weighting of climate goals on scorecards for Executive Directors • Portion of employee's bonus linked to climate-related metrics

Adapted from TCFD, Guidance on Metrics, Targets and Transition Plans (2021)

Source: SCR Certificate (2023)

Reporting

The credibility of net-zero targets relies on how organizations disclose their targets and plans to external stakeholders. Various sustainability-related standards have been introduced by independent bodies to redefine the scope of financial disclosure. **The Task-force on Climate-related Financial Disclosure (TCFD)** is the leading force and baseline setter for climate risk disclosures, with over 2600 organizations supporting its recommendations. Some jurisdictions, including **Brazil, the EU, Hong Kong, Japan, New Zealand, Singapore, Switzerland, and the UK**, have made **TCFD-aligned reporting mandatory**, with more to follow. Net-zero transition plan disclosure standards are only beginning to emerge now, with the **TCFD**, **GFANZ**, and the **UK's Sustainability Disclosure Requirements (SDR)** encouraging and introducing transition plan disclosure requirements for

members and companies. In the UK, preparing and publishing net-zero transition plans will become mandatory for financial institutions and listed companies by 2023. **The International Sustainability Standards Board (ISSB)** aims to create comprehensive and lasting carbon-related financial disclosure standards and has published initial exposure drafts of its general sustainability and climate-related corporate disclosures, which seek to align with recommendations provided by other organizations. A key controversy in the development of net-zero disclosure standards is whether such standards should consider double materiality, which adds to the materiality concept by disclosing activities that could be material to society and the environment. The TCFD and ISSB are essential organizations for the future of net-zero financial disclosure, as well as national regulatory bodies that are increasingly looking to include net-zero disclosure requirements.

Goals of key disclosure and reporting standard setters

Organization	Main goal
TCFD	Improve and increase reporting of climate-related financial information by developing disclosure recommendations.
SASB	Identify the subset of ESG issues most relevant to financial performance in each of 77 industries and create disclosure standards around them.
ISSB	Deliver a comprehensive global baseline of sustainability-related disclosure standards.
GRI	Impact reporting; deliver the highest level of transparency for organizational impacts on the economy, the environment, and people.

Source: SCR Certificate (2023)

BULLET POINTS:

- Achieving a balance between global greenhouse gas sources and sinks (net zero emissions) is necessary to stabilize global temperatures. To limit global average temperature increases to 1.5°C, global emissions must halve by 2030 and reach net zero by 2050, according to the IPCC.
- Countries, sub-national governments, and companies are submitting net-zero pledges, but these differ in ambition and credibility. Some only apply to carbon emissions while others cover all greenhouse gases.
- National net-zero pledges cover all emissions produced within a country's boundaries, requiring the reduction of all domestic greenhouse gas emissions and the removal of any remaining net domestic flows via carbon sinks. There is no globally recognized standard for sub-national communities or corporations, but the Science-Based Target Initiative may become one.
- Transition plans can add credibility to net-zero pledges by demonstrating alignment with broader organizational strategies and a meaningful action plan.
- Net-zero targets are not enough without credible pathways and interim targets to ensure a timely transition.
- Carbon-related metrics track progress along a net-zero pathway, help select projects, and compare entities to peers. Stakeholder needs and public disclosure must also be considered.
- Portfolio alignment tools help financial institutions assess if counterparties are on a net-zero transition path, but portfolio decarbonization alone may not support economy-wide decarbonization or mitigate climate risk exposure.
- The net-zero disclosure landscape is evolving, with the TCFD and ISSB as leaders, and new government-backed initiatives trying to incorporate these standards into law.

PRACTICE QUESTIONS

1. What is the concept of net-zero emissions?

   A) A balance between emissions and GHG removals
   B) A balance between emissions and carbon capture
   C) A balance between emissions and geologic storage
   D) A balance between emissions and temperature changes

2. What is the 2018 IPCC Special Report on 1.5°C (SR 1.5) about?

   A) The report outlines the effects of 1.5°C of global warming.
   B) The report outlines the effects of 2°C of global warming.
   C) The report outlines the effects of 0.5°C of global warming.
   D) The report outlines the effects of global cooling.

3. What was the goal of the Paris Agreement?

   A. To increase global greenhouse gas emissions.
   B. To limit the increase in global average temperature to well below 2°C above pre-industrial levels.
   C. To increase the level of global warming to 2°C.
   D. To increase the level of global warming to 1.5°C.

4. Which country has pledged to reach carbon neutrality by 2045?

   A. China
   B. India
   C. Sweden
   D. Germany

5. What is the goal of cities and regions seeking to reach their targets?

   A) Reach “net zero” emissions
   B) Reach “zero waste”
   C) Reduce emissions from transportation systems
   D) Increase emissions from buildings

6. What is the focus of the UN Race to Zero campaign?

   A. Mobilizing new entities to sign up to net zero
   B. Defining rigorous standards and supporting members in operationalizing their targets
   C. Setting up a High-Level Expert Group to propose standards for assessing targets published by non-state actors
   D. All of the above

7. What is an example of a metric under the metric category "Transition risks"?

   A. Revenue associated with water withdrawn and consumed in regions with high base-line water stress
   B. Concentration of credit-exposure to carbon-related assets
   C. Investment in climate adaptation measures (e.g., flood defenses, location changes)

D. Internal carbon price (e.g., a company internal tax on emissions that is invested into sustainability projects)

8. Is net-zero transition disclosure mandatory for UK financial institutions and listed companies by 2023?

   A. Yes
   B. No
   C. It is still unclear
   D. The ISSB has excluded it from the scope of its requirements

9. What is the main goal of the SASB?

   A) Deliver a comprehensive global baseline of sustainability-related disclosure standards
   B) Identify the subset of ESG issues relevant to financial performance
   C) Improve reporting of climate-related financial information
   D) Impact reporting and transparency for organizational impacts

10. What is the main goal of the TCFD?
    A) Develop a comprehensive baseline of sustainability-related disclosure standards
    B) Improve reporting of climate-related financial information
    C) Identify the subset of ESG issues relevant to financial performance
    D) Impact reporting and transparency for organizational impacts

ANSWERS FOR PRACTICE QUESTIONS

CHAPTER 1	
1.	Correct answer: C. They both reflect sunlight and trap heat in the atmosphere. The reading states that clouds can have both a cooling and warming effect on the Earth's energy balance, depending on their type and altitude. Some clouds reflect sunlight back into space, while others trap heat in the atmosphere. C. They both reflect sunlight and trap heat in the atmosphere
2.	Answer: c) Biomass burning is the primary source of black carbon emissions. Black carbon is formed when organic matter burns incompletely and is released into the atmosphere. Biomass burning, such as wildfires and agricultural waste burning, is the main source of black carbon emissions. Industrial processes, residential and commercial buildings, and transportation also contribute to black carbon emissions, but to a lesser degree. c) Biomass burning
3.	Explanation: C. fossil fuels is the primary source of human-caused sulfur dioxide emissions. The other options, while they do contribute to sulfur dioxide emissions, are not the primary source.
4.	Explanation: According to the reading, positive feedbacks are processes that amplify changes in the climate system while negative feedbacks are processes that reduce changes in the climate system. Option B is incorrect because it is the opposite of what positive and negative feedbacks do. Options C and D are incorrect because positive and negative feedbacks can occur in various parts of the Earth's climate system, not just in the atmosphere or ocean.
5.	Correct answer: C) Changes in regional weather patterns. The collapse of the Gulf Stream could result in changes in weather patterns, particularly in Europe. The other options may be related to climate change but not specifically to the collapse of the Gulf Stream. C) Changes in regional weather patterns
6.	"Explanation: According to reading number 1, a climate tipping point is a point at which small changes in climate can lead to large, irreversible changes in the climate system. Answer a is incorrect because it suggests that the climate is in a stable state, which is not true as the climate is constantly changing. Answer c is incorrect because the climate will not return to its pre-industrial state. Answer d is incorrect because the climate will continue to change." b. A point at which small changes in climate can lead to large, irreversible changes in the climate system
7.	Explanation: Building a dam can lead to an increase in flooding downstream and also can impact the freshwater ecosystem. The other options are examples of adaptive measures that can have benefits. d. Building a dam to regulate water flow in a river
8.	c) By ignoring the potential negative side-effects of adaptation measures.
9.	Explanation: reading number 1 states that geothermal energy is only available in certain geographic regions where there is enough heat coming from the Earth's interior. A is incorrect because reading number 2 states that the cost of geothermal energy has been decreasing in recent years. C is incorrect because reading number 3 states that many countries are investing in and supporting the development of geothermal energy. D is

	incorrect because geothermal energy is not intermittent and can provide consistent power. B) Limited geographic availability
10.	"Answer: B. 1200 GtCO2 Correct: According to reading number 1, the Paris Agreement aims to limit global warming to below 2°C with efforts to limit it to 1.5°C, and this requires limiting total CO2 emissions from human activities to a maximum of 1200 GtCO2. Incorrect: Option A is incorrect as the limit is much lower than 2000 GtCO2. Option C and D are also incorrect as the limit is not 1300 GtCO2 or 1500 GtCO2." B. 1200 GtCO2
CHAPTER 2	
1.	Right answer: B. The Brundtland Commission Explanation: The final report of the Brundtland Commission proclaimed sustainable development to be compatible with economic growth and defined it as ""development that meets the needs of the present without compromising the ability of future generations to meet their own needs"". This has since become the most cited and widely accepted definition of sustainable development.
2.	"Right answer: A and D Explanation: ESG scores and metrics are used by financial firms for ""screening companies for inclusion in ESG investment funds"" and for ""insight into banks', insurers', and investors' firm-level ESG policies that are integrated into their lending, underwriting, and investment practices.""
3.	"Answer: A. ESG is an abbreviation used by the financial industry. The book states that ""The term ESG was coined in a 2005 report by the UN Global Compact, which was endorsed by a coterie of investment firms, including ABN Amro, Goldman Sachs, and Westpac. Use of the abbreviation was solidified when it was embedded into the UN Principles for Responsible Investment, launched in 2006.""
4.	"Correct answer: C. Environmental, economic and social goals Explanation: The 17 Sustainable Development Goals (SDGs) cover a much broader set of policies and areas than the previous Millennium Development Goals (MDGs). They range from environmental and economic to social goals.
5.	"Right Answer: A) Companies having a broader obligation to society Explanation: The book mentions that the concept of corporate social responsibility (CSR) is about a corporation having a broader obligation to society and not just focusing on financial performance.
6.	"Answer: C. To promote the incorporation of ESG in investment decisions and increase disclosure on ESG issues Explanation: The book mentions that the PRI group, launched in 2006, has played a similar role as the WBCSD for investors. By joining PRI, investors commit to incorporating ESG in investments and decisions, seeking disclosure on ESG issues from investee firms, and more.

7.	"Right answer: B) To assess an organization's impact on the environment and society Explanation: ESG evaluations are used to assess an organization's commitment to sustainability and responsibility towards the environment and society.
8.	"Answer: A. Explanation: The Global Sustainable Procurement Alliance is an initiative that promotes sustainable procurement practices. It provides guidance, training, and resources to organizations to help them make procurement decisions that are environmentally, socially and economically sustainable.
9.	"Right answer: A. Explanation: By considering the entire life-cycle of a product, the LCA process provides a comprehensive evaluation of the environmental impact of a product, including all stages of its life-cycle, from raw material extraction to disposal or recycling.
10.	"Right answer: A. The act of making false or misleading claims about the environmental benefits of a product or service Explanation: Greenwashing refers to the act of making false or misleading claims about the environmental benefits of a product or service in order to gain an advantage in the market. This is often done without any real evidence to support the claims.
CHAPTER 3	
1.	"Answer: B Explanation: Climate-related financial risks, referred to as simply climate risk, are the financial risks linked to climate change. Explanation for wrong answers: A. Natural disasters are not necessarily related to climate change C. Climate risk is a subset of environmental issues. D. Renewable energy is not directly related to climate risk.
2.	"Right Answer: B. Physical risk and transition risk Explanation for Right Answer: Physical risks arise from the physical climate (and weather) impacts that result from the changing climate, whereas transition risks arise from the economic transformation and any dislocation needed to drastically reduce, and eventually eliminate, net greenhouse gas emissions. Explanation for Wrong Answers: A. Physical risk and economic risk is incorrect because economic risk is not a category of climate risk. C. Acute and chronic hazards is incorrect because acute and chronic hazards are sub-divisions of physical risk. D. Carbon taxes and technological changes is incorrect because carbon taxes and technological changes are drivers of transition risk, not categories of climate risk.
3.	"Right Answer: C. Lack of preparation for climate change mitigation Explanation for Right Answer: Vulnerability at the corporate level can refer to the lack of preparation for such issues as climate change mitigation and adaptation planning. Explanation for Wrong Answers: A. Flood pumps is incorrect because flood pumps are an example of physical risk vulnerability, not transition risk vulnerability. B. Rising sea levels is incorrect because rising sea levels is an example of a physical risk hazard, not an example of vulnerability.

	D. Carbon taxes is incorrect because carbon taxes is a driver of transition risk, not an example of vulnerability.
4.	"Right Answer: A. Assets that have suffered devaluations or conversion to liabilities Explanation: According to the book, stranded assets are defined as assets that have ""suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities"". Wrong Answer: B. Assets that have not been used to their full potential Explanation: This is not the exact definition of stranded assets as provided in the book. Wrong Answer: C. Assets that have been impacted by environmental risks Explanation: This is a possible cause of stranded assets, but it is not the definition. Wrong Answer: D. Assets that have been impacted by market trends
5.	"Correct answer: B Explanation: The TCFD metrics and targets are focused on assessing climate-related risks and opportunities. Explanation for wrong answers: A. While climate change mitigation strategies may be part of the firm's strategy, it is not the primary focus of the TCFD metrics. C. Environmental sustainability is a broader concept and not the specific focus of TCFD metrics. D. While governance structures at the board level are important, they are not the primary focus of TCFD metrics.
6.	"Answer: C) Both A and B Explanation: The book mentions that with climate data in hand, mapping exposures to climate hazards only requires precise location data to cross-compare with climate hazards.
7.	Answer: C. Rising average temperatures Explanation: Chronic climate hazards include gradual, long-term trends, like rising average temperatures and rising sea levels. Option A is incorrect because floods are an acute climate hazard. Option B is incorrect because hurricanes are an acute climate hazard. Option D is incorrect because rising sea levels is a chronic climate hazard.
8.	"Correct answer: D Explanation: To assess the vulnerability of physical assets to climate risks, location data, adaptive infrastructure information, and climate engineering evaluations are all necessary. Explanation for wrong answers: A. Location data is important but not sufficient to assess vulnerability B. Adaptive infrastructure information is important but not sufficient to assess vulnerability C. Climate engineering evaluations are important but not sufficient to assess vulnerability
9.	"Right answer: C) Both transition risk and physical risk. Explanation: According to the book, stranded assets can be caused by both transition risk (for example, coal mines or oilfields) and physical risk (for example, facilities in vulnerable areas without adequate flood defenses). Wrong answer: A) Only transition risk.

	Explanation: A is incorrect because stranded assets can also occur due to physical risks, such as increased frequency of climate-induced droughts or sea level rise and coastal flooding. The definition of stranded assets has been expanding and includes assets that are stranded by both transition and physical risks, not just transition risks.
10.	"Answer: A. Providing support for sectors that are losing out Explanation: According to the book, ""Thus, providing adequate support for sectors that are losing out in a low-carbon future and generating new employment opportunities in low-carbon sectors are critical to ensuring a just transition."" B, C, and D are not mentioned as necessary steps to ensure a just transition.
	CHAPTER 4
1.	"Right answer: C. United Nations Framework Convention on Climate Change (UNFCCC) Explanation: The first global agreement on climate change was the formation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. Wrong answers: A. The Paris Agreement - This was formed in 2015, not in 1992. B. The Kyoto Protocol - This was formed in 1997, not in 1992. D. None of the above - The UNFCCC was formed in 1992, so it is not none of the above.
2.	"Right answer: D. To provide a framework for addressing climate change - The UNFCCC is described as the first global agreement on climate change and its purpose is to provide a framework for addressing climate change. Wrong answers: A. To reduce emissions - The book mentions that emissions reductions are a goal of later agreements like the Kyoto Protocol and the Paris Agreement. B. To increase sustainability - The book does not mention the UNFCCC having a specific goal of increasing sustainability. C. To increase private sector practices - The book does not mention the UNFCCC having a specific goal of increasing private sector practices.
3.	"Answer: B) The widespread recognition of the human impact on climate change. Explanation: The book mentions that ""the strong human influence on climate solidi-fied, leading to the formation of the Intergovernmental Panel on Climate Change (IPCC) in 1988, a UN-convened organization of scientists, and soon thereafter to the United Nations Framework Convention on Climate Change (UNFCCC), a UN body dedicated to climate change"". A) is incorrect because it was not the discovery of the greenhouse effect that led to the formation of IPCC but rather the recognition of the human impact on climate change. C) is also a partially correct answer because ""One important debate played out both within academia and among policymakers over the optimal level of emis-sions reductions"" and ""Another important open question revolves around the allo-cation of (moral) responsibility, the relationship between a country's wealth and historical emissions and the potential trade-off between emissions and economic development"". D) is incorrect because the cooling trend observed in the 1950s and 1960s was not a factor in the formation of IPCC.
4.	Answer: B Explanation: North America accounts for 29% of global cumulative emissions as of 2017

5.	"Answer: A) A form of carbon tax Explanation: Carbon pricing refers to policies that impose a price per ton of CO2 emitted, either through a carbon tax or a cap-and-trade scheme. Carbon taxes are considered a classic way of internalizing the social cost of carbon emissions, while cap-and-trade schemes cap the total amount of emissions but allow emissions permits to be traded between participants.
6.	Correct answer: D. To promote the collaboration between the public and private sector in coalitions Explanation: America's Pledge was launched by entities still committed to the Paris Agreement after the decision by President Donald Trump's administration to withdraw from the Paris Agreement. The purpose of America's Pledge was to promote the collaboration between the public and private sector in coalitions, as described in the book.
7.	"Right answer: C. To encourage the uptake of electric vehicles Explanation: EV purchase subsidies are implemented to encourage uptake of electric vehicles, which are far less emissions-intensive and produce no tailpipe emissions.
8.	Right answer: B. The oversight of specific financial institutions for financial soundness Explanation: Microprudential supervision is the oversight of specific financial institutions (usually banks and insurers) for financial soundness. Central banks and supervisors have moved to integrate climate change into this area of supervision. Wrong answer: A. The examination of the stability of the broader financial system Explanation: This is the definition of macroprudential supervision, not microprudential supervision Wrong answer: C. The incorporation of climate issues into traditional monetary policy is still limited Explanation: This is correct as mentioned in the book, ""some have even moved to incorporate climate issues into traditional monetary policy, though this practice is still limited."" Central banks are focusing more on microprudential supervision and macroprudential supervision rather than incorporating climate issues into traditional monetary policy.
9.	"Correct answer: B Explanation: The policy enforcement of sustainable investment and disclosure has to do with consumer protection, specifically combating mis-selling or misleading advertising of products to consumers. The goal is to protect consumers from false advertising of products marketed as sustainable.
10.	"Explanation: The correct answer is B. The Net Zero Asset Managers Initiative is a group of 37 investors who have committed to aligning their entire portfolios with the goal of net-zero greenhouse gas emissions by 2050, including full alignment with a 1.5°C scenario. Explanation for wrong answers: A. The Science-Based Targets Initiative focuses on sector-based targets for decarbonization, but not related to the Net Zero Asset Managers Initiative. C. Extinction Rebellion is a climate-focused civil disobedience movement, but not related to the Net Zero Asset Managers Initiative.

	D. Extinction Rebellion seeks to disrupt society to highlight the impact of climate change, but not related to the Net Zero Asset Managers Initiative.
	CHAPTER 5
1.	"Correct answer: D Explanation: The trend toward sustainable finance transactions, products, and offerings has been carried out by mainstream banks, insurers, asset managers, asset owners, stock exchanges, ratings agencies, and other parts of the financial system. There has also been a rise in smaller, specialist pure-play green or ESG financial firms. Wrong answer explanations: A. Mainstream banks and asset managers are part of the financial organizations that have embraced sustainable finance, but not all of them. B. While small, specialist green financial firms have emerged as well, this answer is not inclusive of all the organizations that have embraced sustainable finance. C. Stock exchanges and ratings agencies are also among the financial organizations that have embraced sustainable finance, but this answer does not include all of them.
2.	"Answer: C. Negative/exclusionary screening Explanation: According to the book, ""the GSIA definition includes negative/exclusionary screening (where the shares of certain types of companies such as weapons manufacturers are left out of portfolios) as a type of sustainable investing, accounting for around half of the total."" Explanation for wrong answers: A. ESG integration and shareholder engagement are the second and third largest categories in the GSIA survey, not the largest. B. Shareholder engagement is the third largest category in the GSIA survey, not the largest. D. Impact investing is not mentioned as a type of sustainable investing accounting for half of the total in the GSIA survey.
3.	"Right answer: A. 35% Explanation: The book mentions that the assets grew by over a third (35%) in just two years from 2016.
4.	"Right answer: C Explanation: The comprehensive accounting assembled bi-annually by the Climate Policy Initiative is widely seen as a gold standard in tracking climate finance flows and provides a comprehensive break-down by source, instrument, and targeted sector, providing an in-depth analysis.
5.	"Right answer: A Explanation: The tallies show that 78% of financing in higher-income OECD countries is from domestic sources.
6.	"Answer: B) 2017 Explanation: The founding year of the ""Climate Action 100+"" is 2017 as mentioned in the book.
7.	"Answer: C. A bond used for social benefits Explanation: Social bonds are bonds with earmarked proceeds for projects that will bring social benefits. They were first introduced by Spain's Instituto de Crédito to finance small and medium enterprises in disadvantaged parts of Spain.

8.	"Right Answer: A. A small number of banks and a borrowing company Explanation: The book states that green or sustainability loans tend to be an agreement between a small number of banks and a borrowing company, like typical corporate loans. Wrong Answer: B. All kinds of private and public entities Explanation: All kinds of private and public entities use green and other sustainability bonds to raise funds, not green or sustainability loans.
9.	"Answer: D. All of the above Explanation: Green bonds differ from typical corporate or government bonds because they are labeled separately, their proceeds are ring-fenced, and the use of proceeds is reported to prospective and current bondholders.
10.	"Answer: A) Percentage of sales revenue from low-carbon products is the correct answer. The book mentions that Volution agreed a GBP 150 million sustainability-linked revolving credit facility tied to this KPI. Explanation: The other options are KPIs mentioned in the sustainability-linked bonds and loans of DSM, Chanel, and Schneider Electric.
CHAPTER 6	
1.	"Correct Answer: A Explanation: Risk management is defined as a structured approach to reducing the impacts of uncertain occurrences, as stated in the book. Wrong Answer: B Explanation: While weather is related to climate, monitoring the weather is not the main focus of risk management. Wrong Answer: C Explanation: While financial portfolios may be impacted by climate risk, risk management is not limited to just financial portfolios Wrong Answer: D Explanation: While measuring climate change is important for understanding and managing climate risk, it is not the sole focus of risk management.
2.	"Right Answer: A. The ability of a borrower to pay back a loan Explanation: Credit risk measures the creditworthiness, or the ability a borrower has to pay back a loan. Wrong Answer: B. The interest rate of a loan Explanation: The interest rate of a loan is not directly related to credit risk. The interest rate may change based on credit risk, but credit risk itself is measured by the borrower's ability to pay back a loan. Wrong Answer: C. The amount of a loan Explanation: The amount of a loan is not directly related to credit risk. The amount of a loan may affect the credit risk, but credit risk itself is measured by the borrower's ability to pay back a loan. Wrorg Answer: D. The duration of a loan Explanation: The duration of a loan is not directly related to credit risk. The duration of a loan may affect the credit risk, but credit risk itself is measured by the borrower's ability to pay back a loan.
3.	"Right answer: C) Losses for the institution Explanation: The book mentions that ignoring or underplaying the effects of physical and transition climate effects can lead to losses for the institution. Wrong answer: A) Increased productivity and acuity

	Explanation: The book mentions that excess heat can have harmful effects on worker productivity and acuity, but inadequate training and management attention towards climate effects would lead to losses for the institution, not increased productivity.
4.	"Answer: A. The risks are so concentrated that the risk of underwriting affected facilities and properties in those areas can grow too high to be economical Explanation: The problem with climate risk, especially some types of physical climate risk, is that the risks become so concentrated that the risk of underwriting affected facilities and properties in those areas can grow too high to be economical. Wrong answers: B. The risks are not concentrated enough - This is incorrect as the risks are so concentrated that the risk of underwriting affected facilities and properties in those areas can grow too high to be economical. C. The risks are not affected by climate change - This is incorrect as climate risk is affected by climate change, especially physical climate risk. D. The risks are affected by natural disasters - This is not entirely true as climate risk is affected by climate change, not just natural disasters.
5.	"Answer: C. Appropriate analytical tools Explanation: The book states that gauging climate risk accurately requires appropriate analytical tools to understand the application of multiple types of data to the user's needs. A. Topographical data - This is a part of the data required to gauge physical risk, but not the factor required to understand the application of data. B. Locational data of assets - This is also a part of the data required to gauge physical risk, but not the factor required to understand the application of data. C. Appropriate analytical tools - This is the correct answer as the book states that appropriate analytical tools are required to understand the application of multiple types of data to the user's needs. D. Historical data and climate models - While this is a part of the data required to gauge physical risk, it's not the factor required to understand the application of data.
6.	"Right answer: B. Proportional amount invested or corporate revenues Explanation: The book mentions that many portfolio-level approaches to transition risk start with numbers proportional to an amount of an invested amount or of corporate revenues, rather than simply total absolute emissions. Wrong answers: A. Total absolute emissions - This is incorrect because the book mentions that portfolio-level approaches do not focus on total absolute emissions. C. Impacts of risks on a particular firm - This is incorrect because the book mentions that portfolio-level analysis is different from understanding the impact of risks on a particular firm. D. Stress testing of the portfolio - This is only partially correct as the book mentions that stress testing is one of the risk-based approaches to transition risk.
7.	"Correct Answer: B. To set expectations on climate Explanation: The book mentions that the tone from senior leadership should convey expectations on climate. Incorrect Answers: A. To enforce employee behavior: The book mentions that employee behaviors and initiatives that are in line with strategic corporate priorities should be welcomed and encouraged, but not necessarily enforced by senior leadership. C. To implement climate risk management strategies: The book mentions the role of senior leadership in setting expectations on climate, not implementing strategies.

	D. All of the above: While all of these actions could be important for senior leadership, the book specifically mentions setting expectations on climate.
8.	"Correct Answer: D. All of the above Explanation: Communication, Reporting, and Disclosure are all considered integral parts of successful ERM. Wrong Answer Explanation: Option A is incorrect because communication is only one aspect of successful ERM. Option B is incorrect because reporting is only one aspect of successful ERM. Option C is incorrect because disclosure is only one aspect of successful ERM.
9.	"Correct Answer: D. All of the above Explanation: Infosys' monitoring system tracks water tables in each geographic area, storage capacity of rainwater on each office campus, and availability and cost of water for delivery via water tankers. All of these criteria have specific thresholds that, if crossed, alert management to allow for follow-up measures. Hence, the correct answer is D. All of the above. Explanation for wrong answers: A. Water tables in each geographic area - This is only one aspect of the monitoring system, so this answer is incorrect. B. Storage capacity of rainwater on each office campus - This is also only one aspect of the monitoring system, so this answer is incorrect. C. Availability and cost of water for delivery via water tankers - This is also only one aspect of the monitoring system, so this answer is incorrect.
10.	"Answer: B. The analysis of current emissions and future plans to reduce emissions Explanation: The book mentions that transition risk analysis is not only about current emissions but also about whether companies have solid and credible plans to reduce emissions in the future and align with national and international goals. This type of analysis refers to evaluating both the current emissions and future plans of a company to reduce emissions. C, D, and A are all discussed in the book, but they are not the definition of transition risk analysis.
11.	"Right Answer: B. Increased litigation Explanation: The book mentions that the policy, operational, and technological changes required for a transition to a net-zero economy could cause litigation against fossil-fuel companies or other emissions-intensive industries.
12.	"Correct Answer: B Explanation: The book states that policy considerations regarding the rise of credit risk due to climate risk are being increasingly incorporated by major credit ratings agencies. S&P, one of the three major rating agencies, revised its entire outlook on the oil & gas industry due to "[s]ignificant challenges and uncertainties engendered by the energy transition, including market declines due to growth of renewables." Wrong Explanation: A is incorrect because the book clearly states that the credit ratings agencies are incorporating the rise of credit risk due to climate risk. C is correct because the book states that S&P downgraded oil & gas firms ExxonMobil, Chevron, and ConocoPhillips. D is incorrect because the book states that the rise of credit risk due to climate risk is being incorporated, not increased.
13.	"Right answer: A) Legal risk Explanation: The book mentions that legal risk is one of the three categories of operational risk that is particularly important when analyzing climate risk.

	Wrong answer: C) People risk Explanation: People risk is mentioned as a manifestation of climate risk, but it is not one of the three categories of operational risk that is particularly important when analyzing climate risk according to the book.
14.	"Answer: A. A type of risk that only affects the insurance sector Explanation: Underwriting risk is a type of risk that only affects the insurance sector but is still important to single out as it is affected by climate risk, especially physical climate risk, as many other corporations and financial institutions rely on insurance coverage as a crucial part of their risk-mitigation strategies. Wrong answers: B. A type of risk that only affects corporations and financial institutions - This is partially true as corporations and financial institutions rely on insurance coverage as a crucial part of their risk-mitigation strategies but underwriting risk only directly affects the insurance sector. C. A type of risk that affects only individuals - This is incorrect as underwriting risk is a type of risk that affects the insurance sector, not individuals. D. A type of risk that has no effect on any sector - This is incorrect as underwriting risk directly affects the insurance sector and has an indirect effect on other sectors such as corporations and financial institutions.
15.	"Correct Answer: B Explanation: The book mentions that operational risk has ripple effects across supply chains and through to markets, customers, and financial counterparties. Explanation for wrong answers: A) The book mentions that operational risk can have macro effects, not just individual effects. C) The book mentions that operational risk can have effects on the financial sector but not just the financial sector. D) The book mentions that operational risk can have effects on the oil & gas sector but not just the oil & gas sector.
CHAPTER 7	
1.	"Explanation for Right Answer: C) To enhance critical strategic thinking and challenge conventional wisdom Explanation for Wrong Answers: A) To predict the future accurately is not the main purpose of scenario analysis, as it is emphasized that scenario analysis should not be used to accurately predict the future. B) To ensure a firm-wide approach to preparedness was the purpose of scenario analysis developed at Shell in the 1960s, but it is not the main purpose of climate scenario analysis. D) To communicate preparedness to stakeholders is a use of scenario analysis, but not the main purpose.
2.	"Explanation for Right Answer: D) All of the above Explanation for Wrong Answers: A) Scenarios created directly by the Intergovernmental Panel on Climate Change (IPCC) are the most widely used and widely agreed upon reference scenarios. B) Scenarios from the International Energy Agency are widely used. C) Scenarios from various non-profit and academic sources are widely used.
3.	"Explanation:

	D) is correct because the book states that scenario analysis can be used for both capital expenditure investment decisions and high-level strategy setting by non-financial firms. A) is wrong because the book mentions that scenario analysis is used for corporate disclosure by financial firms. B) is partially correct because it is mentioned in the book as one of the uses for non-financial firms. C) is partially correct because it is mentioned in the book as one of the uses for non-financial firms.
4.	"Correct Answer: C. Both A and B Explanation: The book states that to stabilize the climate at any given temperature, whether it is the Paris Agreement's objective of holding the increase in the global average temperature to well below 2°C and pursuing efforts to limit temperature rises to 1.5°C, 2° C, 2.5°C, 3°C, or 4°C, net-zero carbon emissions must be achieved. This requires reducing emissions to zero in every sector possible and balancing out any residual emissions through carbon sequestration. So, both options A and B are correct, which is why the answer is C. Wrong Answer: A. Only reducing emissions to zero Explanation: While reducing emissions to zero is important, it is not enough on its own to stabilize the climate. The book explains that some residual emissions will still exist in certain sectors, and to balance these out, carbon sequestration must also be implemented. Wrong Answer: B. Only carbon sequestration Explanation: Carbon sequestration is important in balancing out residual emissions, but it cannot achieve net-zero carbon emissions on its own. The book states that reducing emissions to zero in every sector possible is also necessary to reach net-zero carbon emissions. Wrong Answer: D. Neither reducing emissions to zero nor carbon sequestration Explanation: The book clearly explains that both reducing emissions to zero and carbon sequestration are necessary to reach net-zero carbon emissions and stabilize the climate. So, option D is incorrect.
5.	"Right answer: C) The most definitive global assessment of the energy sector Explanation: The book mentions that the IEA's annual benchmark, the World Energy Outlook, is considered one of the definitive global assessments of the energy sector. It is widely regarded as a comprehensive and authoritative analysis of the energy sector. Wrong answers: A) The most comprehensive and innovative analysis of the energy sector: This answer is incorrect as the book does not mention that the IEA's World Energy Outlook is the most comprehensive and innovative analysis. B) The most recent and up-to-date assessment of the energy sector: This answer is incorrect as the book does not mention that the IEA's World Energy Outlook is the most recent and up-to-date assessment. D) The most advanced and groundbreaking analysis of the energy sector: This answer is incorrect as the book does not mention that the IEA's World Energy Outlook is the most advanced and groundbreaking analysis.
6.	"Right answer: B) Non-financial corporations Explanation: The book mentions that non-financial corporations typically examine transition risk. Wrong answers:

	A) Financial institutions - The book mentions financial institutions as a separate entity from non-financial corporations, not as the only type of organization examining transition risk. C) Government agencies - The book does not mention government agencies as examining transition risk. D) Environmental organizations - The book does not mention environmental organizations as examining transition risk.
7.	"Answer: C Explanation: The book states that scenario analysis starts with a choice of scenario and parameter setting. A, B, and D are mentioned, but as different things.
8.	"Right answer: A. Emissions scenarios Explanation: Transition risk scenario analysis is very closely and directly tied to emissions scenarios, whether the RCPs, IEA scenarios, or custom-made emissions scenarios. The transition risk results directly from the speed, pace, and scale of the low-carbon transition. Wrong answers: B. Supply chains - Although transition risk analysis for a corporation or financial institution involves evaluating its own operations and supply chains, the book does not mention that it is tied to supply chains. C. Societal and economic choices - Integrated assessment models (IAMs) allow analysis of how societal and economic choices affect each other and the natural world, including the causes of climate change, but the book mentions that transition risk scenario analysis is tied to emissions scenarios, not societal and economic choices. D. Physical processes - IAMs include representations of physical processes (e.g., the carbon cycle), but the book mentions that transition risk scenario analysis is tied to emissions scenarios, not physical processes.
9.	"Answer: C. Better to worse socioeconomic outcomes Explanation: The five SSP scenarios range from better to worse climate change outcomes, based on the evolution of socioeconomic factors such as population growth, economic development, etc. Wrong answers: A. The SSPs do not include climate policy options, but they can be combined with the RCPs to explore these options. B. The SSPs do not calculate emissions trajectories, but they can be used in conjunction with the RCPs to provide a more complete picture of the impact of climate policy options. D. While the IPCC's RCPs and SSPs are widely used as a reference point, the IPCC is not the only organization to have put out scenarios.
10.	"Right answer: D) The amount of solar photovoltaic capacity added annually Explanation: The book mentions that the discrepancy in the IEA's forecasts on renewable energy uptake has been the largest and starkest within the amount of solar photovoltaic capacity added annually. The IEA has consistently underestimated the growth of renewable energy, particularly in the case of solar photovoltaic capacity. Wrong answers: A) The amount of wind capacity added annually: This answer is incorrect as the book does not mention wind capacity as the area of largest discrepancy.

	B) The amount of hydro capacity added annually: This answer is incorrect as the book does not mention hydro capacity as the area of largest discrepancy. C) The amount of nuclear capacity added annually: This answer is incorrect as the book does not mention nuclear capacity as the area where the IEA's previous models were criticized for under-estimation. The book only mentions under-estimation in the growth of renewable energy sources, specifically solar photovoltaic capacity.
11.	"Right answer: D) All of the above Explanation: The book mentions that there are certain common parameters that any scenario analysis has to decide on before starting, no matter what kind of climate risk is being analyzed. This includes the type of climate risk being analyzed, the use of emissions trajectories, and the time lag in the global climate system. Wrong answers: A) The type of climate risk being analyzed - This is only one of the parameters that must be decided on, not the only one B) The use of emissions trajectories - This is only one of the parameters that must be decided on, not the only one. C) The time lag in the global climate system - This is only one of the parameters that must be decided on, not the only one.
12.	"Answer: B and D Explanation: The book states that climate scenario outputs can range from revenues or costs to asset valuations. A is not mentioned as an output. C is marked in red in the table, meaning it only relates to physical risk, not all outputs.
13.	"Answer: C Explanation: The book states that conducting scenario analysis requires analytical choices on scope and methods, including quantitative versus qualitative methods. A and B are not stated as differences. D is not mentioned as a characteristic of qualitative methods.
14.	"Correct answer: d. Integrated Assessment Models (IAMs) Explanation: The book mentions that Integrated Assessment Models (IAMs) are broad-spectrum models designed to allow for an analysis of how societal and economic choices affect each other and the natural world, including the causes of climate change.
15.	"Answer: C) Bottom-up works forwards from where the sector is today, while top-down works backwards from net zero globally. Explanation: The book mentions that bottom-up approach works forwards from where the sector is today, while top-down approach works backwards from net zero globally. Option A) is incorrect as the wording of the approach is reversed. Option B) is incorrect as the descriptions of the focus of the approaches are reversed. Option D) is incorrect as the descriptions of the focus of the approaches are reversed.
CHAPTER 8	
1.	"Right answer: A Explanation: The concept of net-zero emissions is a balance between greenhouse gases entering the atmosphere and those removed via sinks such as geological storage or carbon capture in biomass. This means all global GHG emissions are balanced by corresponding GHG removals. Wrong answer: B, C, and D are incorrect because they only partially describe the concept of net-zero emissions.

2.	"Answer: A Explanation: The 2018 IPCC Special Report on 1.5°C (SR 1.5) outlines the effects of 1.5°C of global warming. Explanation for wrong answers: B) The report does not outline the effects of 2°C of global warming. C) The report does not outline the effects of 0.5°C of global warming. D) The report does not outline the effects of global cooling.
3.	"Right answer: B Explanation: The Paris Agreement was a landmark agreement in which countries committed to halting human-induced climate change by reaching a balance between anthropogenic emissions and removals. The goal of the Paris Agreement was to limit the increase in global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit it to 1.5°C. Wrong answers: A. This statement is incorrect as the Paris Agreement committed to reducing emissions, not increasing them. C. This statement is incorrect as the Paris Agreement aimed to limit global warming to well below 2°C, not increase it to 2°C. D. This statement is incorrect as the Paris Agreement aimed to limit global warming to well below 2°C and pursue efforts to limit it to 1.5°C, not increase it to 1.5°C.
4.	"Answer: C. Sweden Explanation: According to the book, ""Whereas Sweden has pledged to reach carbon neutrality by 2045."" Wrong Answers: A. China - This answer is incorrect as China aims to achieve the goal of carbon neutrality by 2060. B. India - This answer is incorrect as India aims to achieve the goal of carbon neutrality by 2070. D. Germany - This answer does not specify the year by which Germany has pledged to reach carbon neutrality.
5.	"Right Answer: A) Reach “net zero” emissions Explanation: The book mentions that the emissions inventories define the goalposts of what it means to reach “net zero” and that cities and regions seeking to reach their targets will face similar challenges. Wrong Answer: B) Reach “zero waste”, C) Reduce emissions from transportation systems, and D) Increase emissions from buildings are not specifically mentioned as the goal of cities and regions seeking to reach their targets.
6.	"Answer: D Explanation: According to the book, the UN Race to Zero campaign has broadened from simply mobilizing new entities to sign up to net zero, to defining rigorous standards and supporting members in operationalizing their targets. Additionally, the UN Secretary General announced that in 2022 the UN would set up a High-Level Expert Group to propose standards for assessing targets published by non-state actors. Explanation for wrong answers: A, B, and C are all correct components of the UN Race to Zero campaign.
7.	"Right answer: B. Concentration of credit-exposure to carbon-related assets

	Explanation for right answer: The example metric ""Concentration of credit-exposure to carbon-related assets"" is under the metric category of Transition risks as stated in the book. Explanation for wrong answers: A, C, and D are not the correct examples as they belong to different metric categories (Physical risks, Capital deployment, and Internal carbon prices) as stated in the book.
8.	"Answer: A. Yes Explanation: According to the book, preparing and publishing net-zero transition plans will become mandatory for UK financial institutions and listed companies by 2023. Wrong Explanations: B. The book states that net-zero transition disclosure is mandatory for UK financial institutions and listed companies by 2023. C. The book does not mention that it is unclear whether net-zero transition disclosure is mandatory or not. D. The ISSB has excluded double materiality from the scope of its requirements, not net-zero transition disclosure.
9.	"Correct Answer: B) Identify the subset of ESG issues relevant to financial performance Explanation: The main goal of the SASB is to identify the subset of ESG issues most relevant to financial performance in each of 77 industries and create disclosure standards around them. Explanation for wrong answers: A) The ISSB has this main goal, not SASB. C) The TCFD has this main goal, not SASB. D) The GRI has this main goal, not SASB.
10.	"Correct Answer: B) Improve reporting of climate-related financial information Explanation: The main goal of the TCFD is to improve and increase reporting of climate-related financial information by developing disclosure recommendations. Explanation for wrong answers: A) The ISSB has this main goal, not TCFD. C) The SASB has this main goal, not TCFD. D) The GRI has this main goal, not TCFD.

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