CERTIFIED EXPERT IN CLIMATE ADAPTATION FINANCE

Unit 1: Climate Change Science - What is Adaptation?

Frankfurt School
FS-UNEP Collaborating Centre
for Climate & Sustainable Energy Finance

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Certified Expert in Climate Adaptation Finance

Unit 1: Introduction to climate adaptation in the context of climate science

Please note that this is a sample material. The script is not complete and some pages have been deleted.

Symbols

Definition

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Food for Thought

The content of this Sustainable World Academy online course is developed by the Frankfurt School - UNEP Collaborating Centre for Climate & Sustainable Energy Finance (http://fs-unep-centre.org/).

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Content

Abbreviations

°C	Degrees Celsius
AR4	IPCC Fourth Assessment Report
AR5	IPCC Fifth Assessment Report
AR6	IPCC Sixth Assessment Report
CDR	Carbon Dioxide Removal
CH_4	Methane
CO_2	Carbon Dioxide
COMEST	Commission on the Ethics of Scientific Knowledge and Technology
CCS	Carbon Capture and Storage
ECMWF	European Centre for Medium-Range Weather Forecasts
FAR	IPCC First Assessment Report
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIS	Geographic Information Systems
GMSL	Global Mean Sea Level
GMST	Global mean surface temperature
GWP	Global Warming Potential
H_2O	Water Vapour
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least Developed Countries
m^3/a	Cubic Meters per Acre
MM T	Million Metric Tonnes
N_2O	Nitrous Oxide
NASA	National Aeronautics and Space Administration
NDCs	Nationally Determined Contributions
ND-GAIN	The Notre Dame Global Adaptation Initiative
O_3	Ozone
ppm	Parts per Million

SAR	IPCC Second Assessment Report
SIDS	Small Island Developing States
TAR	IPCC Third Assessment Report
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USD	US Dollar
USGCRP	US Global Change Research Program

Learning Outcomes

This introductory unit will present the **science behind climate change** and its physical impact, before moving on to discuss the **impact of climate change on the economy**.

It will first introduce basic concepts of climate change science such as the greenhouse effect, the difference between weather and climate, and the main causes and elements of anthropogenic (human-induced) climate change. This sets the scene to discuss that to prevent dangerous consequences of climate change, a comprehensive set of climate protection measures are required.

The unit will then move on to discuss the impact of climate change on the economy, highlighting mitigation and adaptation as complementary strategies to tackle climate change, and exploring the need for economies to adapt. It will address the question "*what is climate adaptation?*" providing the macro perspective of adaptation before moving on to the micro – or project – perspective of adaptation.

The learning outcomes of this unit are:

- Understanding the basic concepts of climate science and the main drivers of climate change.
- Knowing the challenges and opportunities for economies due to climate change.
- Learning about adaptation as the collective reaction of actors within an economy to a structural change driven by the climate.
- Understanding why it makes sense to look at the project level when thinking about adaptation.

Key skills to be learned

- Familiarity with the basic concepts of climate change.
- Ability to identify an adaptation project, its key characteristics, and its (potential) impact on the wider economy.

Meet Isabella and Paul

Welcome to the "Certified Expert in Climate Adaptation Finance". My name is Paul. I am a farmer and I live in a rural area in Africa. For generations my family has worked in agriculture, intercropping maize, beans, and coffee. Agriculture is heavily dependent on the weather, with farmers needing a steady mixture of sun, warmth, and rain in order to reliably produce these crops. I am used to the growing uncertainty of climate change and the unpredictability of the weather, and the effect this is having on the harvesting seasons and crop quality. Fortunately, my daughter has had a good education and can now explain the climate variables, their impacts, and what that means for me and my business.

Hello! My name is Isabella. I studied Finance at Frankfurt School of Finance & Management in Germany and now work for an international private equity fund. I am responsible for investments in agribusiness in Africa.

Together with my Dad, we will guide you through this course on climate adaptation finance. We will characterise climate adaptation and discuss how to implement and finance adaptation approaches, discussing the complexities and challenges and the many different actors and stakeholders involved. For example, there are many approaches and financing options to support my Dad with tackling the decreasing productivity and crop quality, such as tailored financial investments or diversification. We will guide you through these topics with complementary scripts, web-based trainings and exercises.

1. Introduction

Initial Scenario

Climate change is no longer a theoretical possibility resulting from the calculations of computer models. It is not a problem that happens elsewhere or in the distant future, but rather quite the opposite: it is happening now, and it is happening here at our planet. The vast majority of scientists agree that changes in the global climate, which have been occurring since the middle of the past century, can be explained, among others, by human activities. This opinion is supported by multiple scientific studies[1] and position statements of scientific organisations such as the National Aeronautics and Space Administration (NASA),[2] many of which explicitly agree with the Intergovernmental Panel on Climate Change (IPCC) synthesis reports discussed later in this unit.

The adoption of the Paris Agreement in 2015 by UNFCCC parties is seen as a major milestone in the international climate change negotiations, as it set forth an internationally coordinated – but nationally driven – long-term comprehensive action plan[3]. The plan is to

[1] J. Cook, et al (2016): *Consensus on consensus: a synthesis of consensus estimates on human-caused global warming*, Environmental Research Letters Vol. 11 No. 4, DOI:10.1088/1748-9326/11/4/048002
[2] NASA: Scientific Consensus: *Earth's Climate is Warming*, available at: https://climate.nasa.gov/scientific-consensus/ last accessed July 2021.
[3] Zaman S. et al. (2016): *The Paris Agreement and the Challenges for Climate Change Policy Regime*, http://www.dhakatribune.com/climate-change/2016/11/05/paris-agreement-challenges-climate-change-policy-regime/ ; accessed 07/2021.

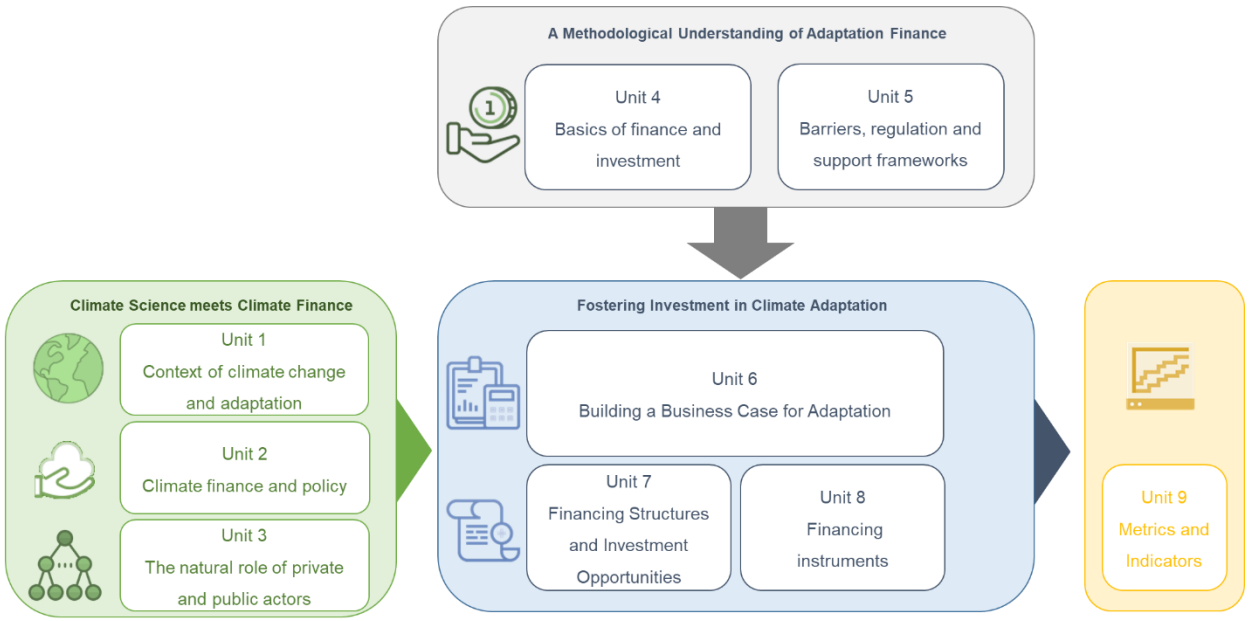
limit the global temperature increase to “well below 2°C” (along with a strong call to limit it further to 1.5°C)[4] and guide the post-2025 climate regime.

Climate change is already underway and certain impacts can no longer be prevented. Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development (Article 2 c of the Paris Agreement) will require a significant increase in funding – with new instruments and approaches required to mobilize a broad range of investors and to achieve scalability in financing climate action. There is a need for a comprehensive transformational change towards a low-carbon climate resilient economy. However, this also presents an opportunity for innovative financing to increase the economic and social resilience to climate impacts.

1.1 Course Outline

The “Certified Expert in Adaptation Finance” course aims to familiarise you with the basics of finance and investment for assessing the financial viability of investments in adaptation projects. It is structured in nine units as outlined below (Figure 1).

Figure 1: Structure of the e-learning course



Source: Own illustration

Unit 1 provide the basic concepts of climate science and climate adaptation and introduced the perspective of structural change. Unit 2 will provide an overview of the climate finance landscape to understand the importance and relevance of adaptation and climate resilience in terms of scale and contribution to climate finance. It will then explore the main building blocks of international adaptation-related policies, looking particularly at the Paris

[4] The Paris Agreement, Dec. 1/CP.21, Annex, UN Doc. FCCC/CP/2015/10/Add.1, at 21 (Jan. 29, 2016), Article 2.1.

Agreement and the post 2025 regime in order to anchor the role of the public sector and public support instruments and policies later in the course. After that, Unit 3 will provide an introductory overview of the natural roles of actors, presenting the interactions between private and public stakeholders.

Unit 4 will provide participants with a methodological understanding of financing at the project level, including understanding the basics of business models, finance and investment, with a focus on investment calculations and key specifics of business cases in general in reference to climate. Unit 5 will introduce the economic perspective on barriers to adaptation investment and demonstrate why markets alone might fundamentally not be able to trigger adaptation investment in a way necessary to mitigate climate change. It will describe the support instruments and support frameworks available across different countries, including dynamic perspective and implications for project risk profiles. Unit 6 continue to build the business case for adaptation, introducing the process of developing a new adaptation business model, or adjusting existing business models, to increase the climate resilience of their portfolio. Following that, unit 7 will first explore which sources of financing are available to finance adaptation business models, building on those analysed in Unit 6, and then unit 8 will focus on which instruments the private sector can use to invest in climate adaptation activities, including 'innovative' instruments.

The concluding unit 9 will explore climate risks and resilience metrics, defining and explaining different metrics that are measurable, computable and comparable, which include mean and variability, recent past, current trends and projection of risk. It will bring the course to a conclusion through a discussion on transformational change.

1.2 How to Use the Course Material

The course provides a mix of methodologies such as scripts, video sequences, web-based training and quizzes available on the e-Campus Canvas platform for the CECAF course.

Further Reading

Please have a look at the "Course Information" section of your e-Campus and read the document "Practical Information".

At the beginning of each unit, an abstract summarizes its main contents, learning outcomes and skills to be learned. Within the scripts there are boxes in different colours to:

- highlight important definitions or key messages,
- deepen your knowledge and engage yourself more with certain topics through further reading, links to videos and homepages,
- see how the discussed subject is implemented in real cases,
- apply the knowledge in exercises; and
- reflect critically about questions

To test your knowledge, each unit ends with a short quiz on the e-Campus platform. You must pass each unit test to unlock the next unit. Together with the exercises, these quizzes will help you prepare for the final exam.

There are multiple ways for students and teachers to interact, like the web-based seminars or the chat open throughout the module. We strongly encourage a lively use of the chat function in the learning platform. Start discussions or provide opinions (ideally marked as such) and share links to interesting related articles online! Typically, participants in this e-learning portfolio come from a wide range of backgrounds in terms or profession, personal experience or world regions. Do not hesitate to share your story, background, experience or ideas with your fellow students. As many of us know from our own experience, a lot of the learning happens through discussion and reflection with other course participants.

2. Basic concepts of climate change

To understand global climate change, it is important to be familiar with the vocabulary of climate scientists. First of all, it is important to understand the difference between "climate" and "weather".

⇨ ***Definition: Weather versus climate***

Climate *describes all meteorological phenomena (e.g. temperature, precipitation, wind) for a period of at least 30 years of average condition of the atmosphere in a certain location.*

Weather *describes short-term and local meteorological phenomena (e.g. wind speed and direction, precipitation, barometric pressure, temperature, and relative humidity).*

The two most basic cycles – the diurnal cycle and the annual cycle – are good places to begin to understand the variability of the weather and climate over time and space.

The diurnal cycle, also known as the daily cycle of weather is prevalent over most of the world, including the remote oceans. Most of us can instinctively predict the daily rise and fall of the temperature or the familiar pattern of a thunderstorm brewing. Research has also shown that the diurnal cycle can impact the climate through a feedback mechanism where the weather's daily effects assimilate over many days, and this can also help to understand the climate and predict its changes. Scientists have a good understanding of how the diurnal cycle of land-surface-heating promotes cloud development and precipitation; however, they do not understand the diurnal cycle over remote oceans, particularly the prominent nocturnal or early-morning peak in rainfall.[5]

In other words, traditionally "climate is what you expect, weather is what you get". Indeed, it is argued that, in the twenty-first century, it is rather "the climate is what you affect, the weather is what gets you".[6]

[5]Physics Today (2016): *The diurnal cycle: A bridge between weather and climate*, https://physicstoday.scitation.org/do/10.1063/PT.5.4024/full/ ; accessed July 2021.
[6] Allen, M. (2003): *Liability for climate change: Will it ever be possible to sue anyone for damaging the climate?* Nature, *421*, pp. 891–892. doi: 10.1038/421891a

2.1 Greenhouse effect

The global climate is not constant; it is subject to constant fluctuations. There are several drivers: the atmosphere has the greatest influence, but it also interacts with other systems like the oceans and ice surfaces, the land surfaces or the biosphere. The driving energy for the exchange between these subsystems is delivered by the sun. Most of the sun's rays penetrate the Earth's atmosphere and hit Earth's surface. These rays are absorbed by the Earth and then emitted as heat radiation. As illustrated in Figure 2. The greenhouse gas effect, a layer of greenhouse gases (GHG) within the atmosphere – primarily water vapour (H_2O) and including much smaller amounts of carbon dioxide (CO_2), methane (CH_4), and ozone (O_3) and nitrous oxide (N_2O) – acts as a thermal blanket for the Earth, absorbing heat and warming the surface to a life-supporting temperature. Without naturally occurring GHGs, Earth's average temperature would be around minus 21°C.[7] The Earth's climate is the result of a simple energy balance, within which the radiation affecting the Earth's surface and the heat radiation back into space are kept in balance.

About 29 percent of the direct solar heating that arrives at the top of the atmosphere is reflected back to space by clouds, atmosphere or particles. 23 percent is absorbed in the atmosphere by water vapour, dust, and ozone. The remaining 48 percent passes through the atmosphere and is transferred from the Earth's surface by evaporation, convection, and thermal infrared radiation. Because GHG molecules in the atmosphere radiate heat in all directions, some are absorbed on the Earth's surface. Thus, the temperature of Earth's surface becomes warmer than it would be if it was heated only by direct solar heating. This heating of Earth's surface incurred by the atmosphere is called the greenhouse effect.[8]

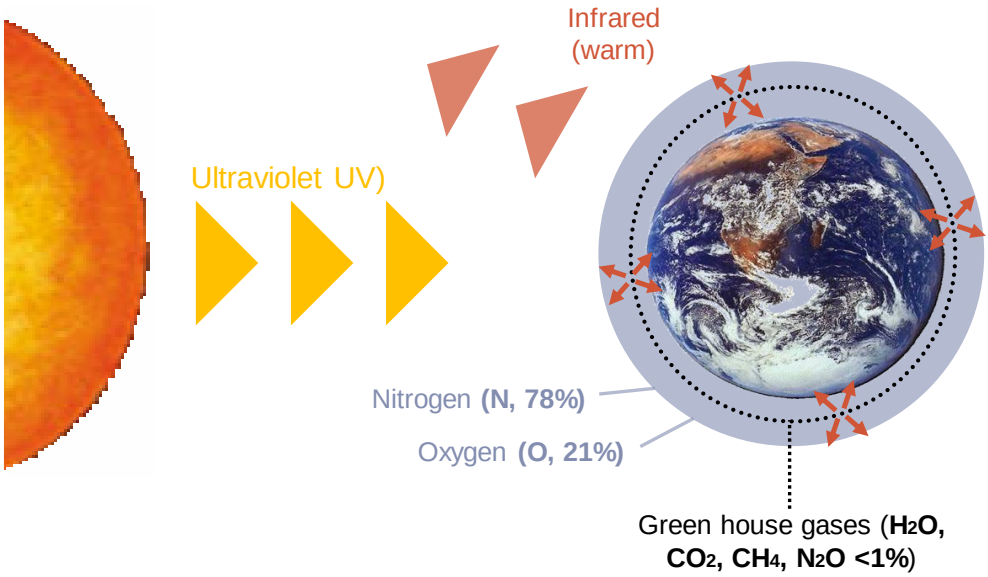
Watch this video

This NASA video describes how carbon dioxide and water vapour cause the earth's greenhouse effect. It also describes how the greenhouse effect maintains the surface temperature of the Earth.

https://www.youtube.com/watch?v=SN5-DnOHQmE

[7] Lacis, A. et al. (2010): *Atmospheric CO2: Principal Control Knob Governing Earth's Temperature*, Science 330, pp. 356–359.
[8] NASA Earth Observatory: *Climate and Earth's Energy Budget*, available at: https://earthobservatory.nasa.gov/features/EnergyBalance ; last accessed July 2021.

Figure 2: The greenhouse gas effect



Source: Own illustration.

The GHGs are contained in different concentrations, or abundance, in the atmosphere – even without human intervention. GHGs can remain in the atmosphere for different amounts of time, ranging from a few to thousands of years. For instance, the atmospheric lifetime of CO_2 ranges from five to 200 years, while methane (CH_4) has a lifetime of approximately twelve years. Therefore, the concentration of gases in the atmosphere, measured mostly in parts per million (ppm)[9], is globally similar, regardless of the emission source.[10] Each ppm by volume of CO_2 in the atmosphere corresponds to approximately 2.13 gigatons of carbon.[11]

The individual GHGs, however, differ in their warming effect. Consequently, the composition of the atmospheric gases ultimately changes the heat radiation from the earth and thus the climate.

[9] Depending on the gases, the concentration can also be measured in parts per billion, and even parts per trillion.
[10] United States Environmental Agency: *Overview of Greenhouse Gases*, available at: https://www.epa.gov/ghgemissions/overview-greenhouse-gases; last accessed June 2021.
[11] Carbon Dioxide Information Analysis Center: *Conversion tables*, available at: https://cdiac.ess-dive.lbl.gov/pns/convert.html; last accessed June 2021.

⇨ ***Definition: Climate Change***

Climate change *refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer.*

Note that the United Nations Framework Convention on Climate Change (UNFCCC), in Article 1, defines climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.' The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes[12].

To better compare the effects of the individual GHGs and to calculate their entire global warming potential, climate scientists have developed standard conversion measures to express all GHG effects in one unit: the so-called CO_2 equivalent.

⇨ ***Definition: CO_2 equivalent***

CO_2 equivalent *is a term for describing different GHGs in a common unit. For any quantity and type of GHG, the amount of CO_2 that would have the equivalent global warming potential (GWP) is calculated by multiplying the emission of a GHG by its GWP for a 100-year time horizon. The Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR5) regularly publishes the GWP values relative to CO_2[13].*

Natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use can also result in climate change. The UNFCCC therefore distinguishes between climate change attributable to human activities (man-made or anthropogenic climate change) and the altering of the atmospheric composition and climate variability attributable to natural causes.[14]

[12] IPCC (2018): *Global Warming of 1.5 ºC*, Special Report, Annex I: Glossary.
[13] Source: Brander, M. and G. Davis (2012): What Do All These Terms Mean, Econometrica.
[14] IPCC (2018): *Global Warming of 1.5 ºC*, Special Report, Annex I: Glossary.

4. Defining Climate Adaptation

As discussed in the previous chapters, economic activity is coupled, in one way or another, with the global climate. Reducing our emissions is typically called *mitigation*.

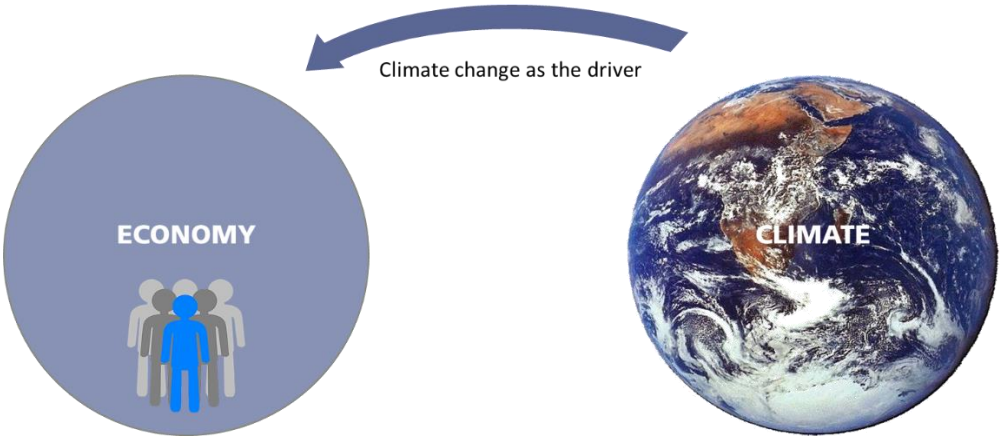
> ***Definition: Mitigation***
>
> ***Mitigation:*** *A human intervention to reduce GHG emissions or enhance the sinks.*
>
> *Mitigation measures are easy to explain but reducing GHG emissions is not easy to accomplish. Measures include the reduction of fossil fuel-based electricity, heat or transport, a shift of diet away from meat and dairy products or enhancing the "sinks" that absorb and store these gases (e.g. oceans, forests and soils). To effectively reduce emissions, we must transit from powering our world with fossil fuels to using clean, renewable energy.*

However, economies also need to adapt! There are many definitions of adaptation, but probably the most influential is that of the Intergovernmental Panel on Climate Change (IPCC) in its Special Report, which defines adaptation as:

> ***Definition: Adaptation***
>
> *In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects*[48].

Mitigation and adaptation are complementary strategies to reduce the risks of climate change.

[48] IPCC (2018): *Global Warming of 1.5 ºC*, Special Report, Annex I: Glossary.



The IPCC definition of adaptation (above) takes the macro perspective, with adaptation as a process of adjustment that global economies and natural systems have to undergo in response to climate change. It clearly identifies climate change as the driver of this adjustment. However, we also need to ask whether what we are doing in terms of adaptation is enough. To do this, we must look at the project level too.

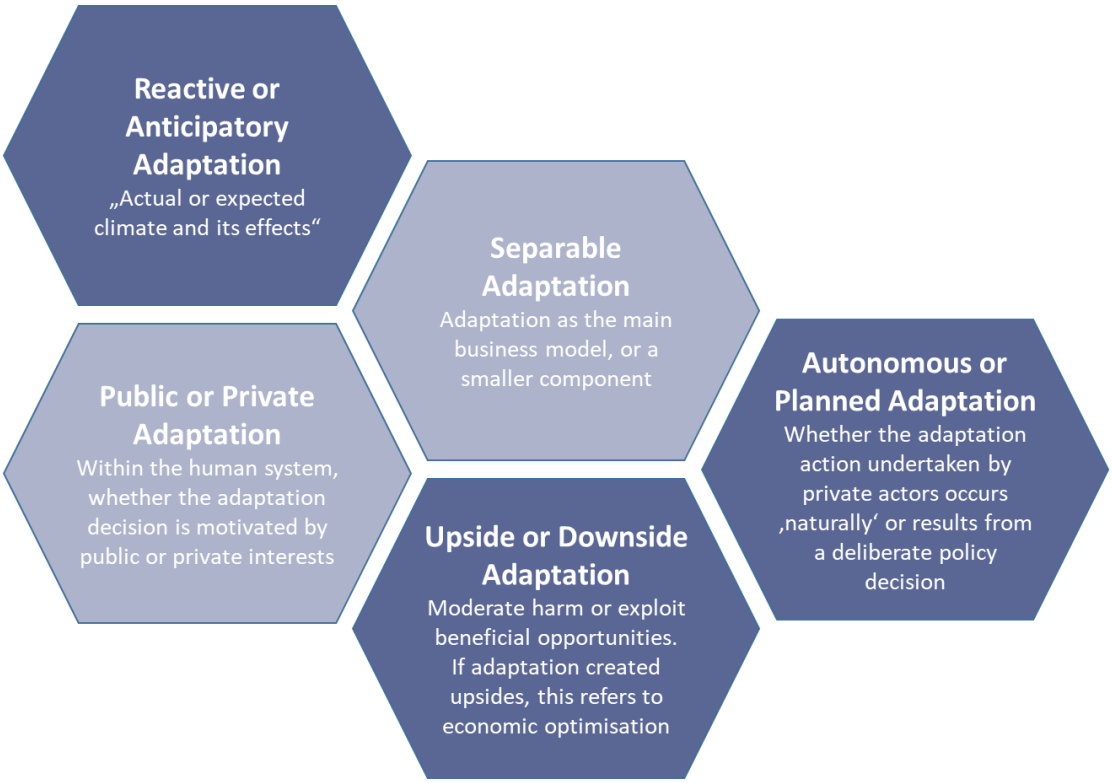
4.1 The Many Faces of Adaptation

Adaptation is a key aspect of climate change. While mitigation looks at how economic activities may slow down climate change, adaptation looks at how economic activities may be shaped by climate change. We show that adaptation can appear with different characteristics depending on the level that we look at and the individual activity that is considered. Depending on these different characteristics, there are different roles for private and commercial actors or governmental institutions.

To identify the different characteristics of adaptation, we first look at adaptation from a macro – or international-level – perspective and then move to the micro – or project-level – perspective.

Looking again at the IPCC (2018) definition of adaptation, we can see two proposed categorisations of adaptation. A much older, 2001 IPCC definition of adaptation also distinguished between anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation. These categorisations provide a useful framework to understand the characteristics of adaptation (see Figure 7).

Figure 7: The Characteristics of Adaptation



Source: Own illustration.

Reactive or anticipatory adaptation

This category differentiates adaptation projects into two categories based on the trigger of the adaptation measure: reacting to observable climate effects and coping with the damages caused by climate change (reactive adaptation), or modelling expected climate (future predictions) and increasing resilience to climate change threats (anticipatory adaptation).

Separable adaptation

Considering adaptation from a private or project perspective, a typical business model describes how an organisation would create, deliver and capture value; a business model for an adaptation project would be no different. Projects undertaken by private actors are always assessed on the risk/return profile of the investment. However, the investment may be a wholly adaptation-related project, or adaptation may comprise only a smaller component within the larger business model. For example, the development of a tourism complex in order to sell it is business as usual for the developer. If the complex is built on a coastal front and the developer develops the coast to protect existing ecosystems and protect the complex from adverse weather, there is an adaptation component within the larger business model. This category seeks to determine whether the main business activity is itself an adaptation activity or whether adaptation is a component that is a part / attached to the main activity. This is discussed in more detail in Unit 6.

Private or public adaptation

This refers to whether the adaptation measures are motivated by public or private interests. This also relates to the arguments we will introduce in Unit 5 (barriers) on whether adaptation provides a private good or generates (accidentally or deliberately) public goods.

⇨ ***Definition: Public and Private Goods***

Private good: *A private good, in the traditional economic sense, is 'rivalrous' and 'excludable'; a private good must be purchased and its goal is profit making.*

Public good*: a public good is 'non-rivalrous' and 'non-excludable'; individuals cannot be effectively excluded from its use, and its use by one individual does not reduce availability of the good to others.*

The developer of a tourism complex expects to generate private goods through the sale of each complex. However, the development of the coastal front will generate a public good and the developer will usually not be compensated for its provision[49]*.*

Upside or downside adaptation

Adaptation seeks to moderate harm, assuming a situation where the effects of climate change are negative or detrimental. In accordance, adaptation should seek to minimise or reduce the harm caused by climate change (downside adaptation). However, looking at the economy as a whole there might also be cases or areas where some climate effects are positive, and a proper reaction may enhance them. Adaptation should also emphasise or optimally use these positive opportunities that come from climate change (upside adaptation). It is important to note that this is from a macro perspective: it is important for society as a whole to benefit from positive opportunities.

⇨ ***Definition: Downside and Upside Adaptation***

Downside adaptation*: 'moderating harm' or making the potential negative consequences of extreme events less extreme or intense, or adjust to expected climate impacts. Resilience can be strengthened by decreasing the probability of occurrence of a hazard, avoiding or reducing its potential effects, and facilitating recovery in the face of damages.*

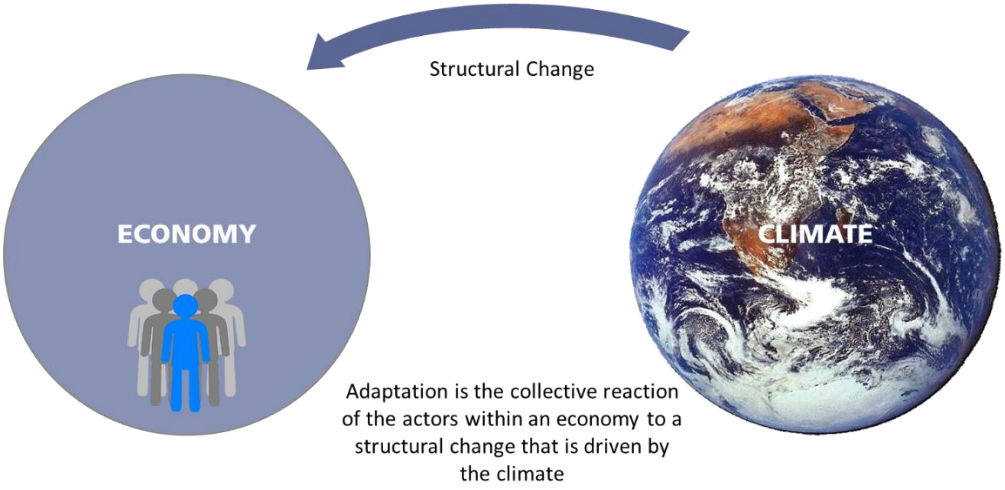
[49] Druce, L., et al. *Characterising Climate Adaptation of MSMEs.*

> ***Upside adaptation**: climate change may lead to new business opportunities or the creation of new markets to which many businesses, and investors react; either by launching new businesses or complementing existing operations through new activities*[50].

Autonomous or planned adaptation

Planned adaptation is where the process of adjustment is the result of policy decisions taken in awareness of the fact that the economy has to adapt; therefore, policymakers make decisions on adaptation measures. Autonomous adaptation refers to measures that take place without any intervention. For example, a business is driven by climate change to implement a new business model or develop a new product. These measures do not need a higher policy coordination process; they happen without this facilitation.

4.2 Structural change



The driver of structural change is exogenous; an action or object originating externally

Adaptation is the collective reaction of the actors within an economy to a structural change that is driven by the climate. This means that the driver of that structural change is completely exogenous. This is a fundamental difference to mitigation, which is a reaction to climate change that also has an impact on climate change. In adaptation, we don't change the climate; we react to it. This becomes important when we move to the project level, as business decisions in the context of adaptation consider "what do we do to

[50] Druce, L., et al. *Characterising Climate Adaptation of MSMEs.*

Frankfurt School - UNEP Collaborating Centre
Frankfurt School of Finance & Management

Adickesallee 32-34
60322 Frankfurt am Main
FS-unep-centre.org/
www.frankfurt-school.de

Frankfurt School Development Finance e-Campus

www.fs.de/e-campus
E-Mail: e-campus@fs.de
Phone: +49 (0)69 154008-624
Fax: +49 (0)69 154008-4624