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Climate change impact on the banking sector: Management of physical and transition risk by financial intermediaries

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Executive summary

Climate change has always occurred in Earth's history. The last few million years have been characterized by a sequence of ice ages followed by warmer periods. However, the discriminating factor of the current scenario is that the climate warming we have been witnessing over about 150 years is anomalous as it is triggered by humans and their activities.

Starting from the industrial revolution, human activities have caused the emission of large amounts of greenhouse gases (from now on GHGs) into the atmosphere, prompting increasingly dramatic consequences on the ecosystem. Atmospheric pollution has come to such a point that global warming is one of the toughest challenges that our society ever had to face. If GHGs emissions will not be slowed down, over the next decades the global community will have to witness an irreversible increase in the amount and impact of natural disasters, as stated by the vast majority of scientists. Regardless of that, the effects of human-driven pollutions are already clear and manifest themselves mainly through:

- a clear rise in global temperature, which has been evidenced by data provided by authoritative agencies such as NASA and the World Meteorological Organization (WMO), stating that the 2011-2020 decade was the hottest on record.
- a rise in sea level, which poses a threat for societies located in coastal areas, and an increase in the acidity of sea water, that endangers the normal functioning and well-being of ecosystems.

That said, climate change is not only a threat for the environment and the society as a whole, but also constitutes a serious risk for the normal functioning of the economy and financial system. That is mainly for two reasons: first, because the increase in the occurrence of extreme weather events will likely damage a huge amount of economic and financial assets worldwide. Second, the expected transition to a lower-carbon economy represents an issue for all those polluting assets on which corporations have invested and that still have a significant useful life, since they will not fit anymore in a greener context and will rapidly lose their value. In other words, the ecologic transition comes with significant risks in terms of expected losses for corporations, especially for the most carbon-intensive ones.

The two risks just outlined, namely **physical** and **transition** risk, represent a relatively new but still highly significant source of risk for companies' cash flows, but will also affect individual mortgage holders indebted to banks.

In this regard, the financial system is extremely concerned as expected losses by corporations and mortgage holders may prevent them to service their debt towards lending banks and financial

institutions themselves, thus possibly leading to financial disruptions. This is why banks are both directly and, most importantly, indirectly exposed to the effects of physical and transition risk.
As the state of health of the financial system is of primarily importance, banks need to be able to make sure that they are not too much exposed towards counterparties that entail high levels of climate risk. In order to do so, as required by supervisory authorities and regulatory bodies such as the EBA and the ECB, banks should develop frameworks that allow an appropriate evaluation of physical and transition risks to which they are exposed by means of their counterparties.
The main purpose of this paper is indeed to examine the advances that financial intermediaries have made over the last years with respect to the integration of climate risk consideration into their strategy setting, governance frameworks and risk management practices. On top of that, the final aim is therefore to get a snapshot of the current level of preparedness of the banking sector in the management of climate-related and environmental risks, also by identifying the strengths and the critical areas where further progresses need to be achieved.

In order to do so, an extensive literature review has been necessary, which has mostly been based on documents issued by supervisory authorities such as the aforementioned EBA and ECB, by single national Central Banks and by individual financial supervisors. On top of that, a key source of information was represented by a set of interviews conducted with Banca Sella's employees operating in the credit granting and risk management areas. Choosing to contact Banca Sella for conducting interviews was due to the fact that, being a bank significantly dedicated to innovation especially with regard to ESG matters, it represented a solid source in the pursuit of adequate solutions on the underlying context. Furthermore, it is an institution which pays great attention to a highly delicate component of the financial system which will be covered in this document, namely that of SMEs. Thanks to these sources, it has been possible to outline the main characteristics of the environment where financial players operate in regard to the climate change context.

The paper begins by generally analyzing why and in what ways the financial system plays a key role in supporting the economy in the green transition, which is mainly done by contributing to a widespread diffusion of sustainable and responsible investments through several means. Such means have been promoted by international organizations like the United Nations (UN) and the EU Commission, and are used in this paper to introduce the actual involvement of the financial sector in the fight and supervision of climate-related matters. The focus is then shifted to more specific topics in regard to the title of this paper. First, a more detailed definition on physical and transition risk is provided, shedding more light on the relation between the corporate and banking sector at climate risk level. Then, after having outlined the possible impacts that climate change can have on banks' financing portfolios and ultimately on their cash flows, it will be provided an overview of the

supervisory initiatives taken at global and European level to mitigate and appropriately manage climate change effects. Among them, it is worth citing the guidelines provided by the TCFD about fair disclosure of climate-related financial information by both economic and financial players, the recommendations issued by the NGFS on the performance of scenario analyses by banks to take into account climate effects under different sets of assumptions, and the guides developed by the EBA and ECB for a successful integration of climate change considerations into banks' business strategy, corporate governance, and risk management frameworks.

Overall, by outlining the supervisory and regulatory landscape where financial intermediaries operate, the first chapter served as a quite specific introduction on the topic that will be addressed more in depth over the subsequent two chapters.

The following section represents the central body of the paper. The chapter begins with the analysis of the bottom-up stress test that the ECB has conducted in 2022 on a set of supervised significant banks. Through the study of ECB documents such as "2022 climate stress test", "Banks gearing up to manage risks from climate change and environmental degradation" and "Good practices for climate-related and environmental risk management" it has been possible to assess that most of the supervised banks have started to integrate climate-related and environmental risks into their internal management frameworks, even though such a process is still at an initial stage and further progresses need to be achieved. In this context, financial intermediaries overall recognize that climate considerations represent a major issue to be addressed in order to preserve financial stability. However, they are currently facing some challenges that prevent them to accurately develop appropriate methodologies for the assessment of climate risk. The main challenge is represented by the lack of reliable data to assess the actual exposure of banks' counterparties to physical and transition risk. In fact, with respect to physical risk, it is not always straightforward to determine whether a certain building located in a certain area is actually at risk of being impacted by extreme weather events, and especially to what extent. Furthermore, about transition risk it is currently challenging to identify the Energy Performance Certificates (EPCs) of mortgage-backed houses and the actual emissions of indebted corporations, especially for what concerns *Scope 3* emissions which are relative to the whole supply chain of companies and that represent the most significant share of emissions under analysis. This issue is further exacerbated by the fact that a significant share of companies, among which all the SMEs, currently do not have any obligation or incentive to invest in the development of methodologies to correctly take account of GHGs emissions that they produce.

After having identified the main challenges in this context, attention is dedicated to the remedies which are about to be implemented to overcome these issues. On one side, supervisory authorities and regulatory bodies are currently working on the development of sets of regulations to enhance the

disclosure by companies on their ESG information. As an example, with the entry into force of the Corporate Sustainability Reporting Directive (CSRD), many more corporations will have to provide a Non-Financial Disclosure (NFD), including non-listed SMEs starting from 2026. On top of that, to ensure full comparability of information, the EBA has developed a set of standard qualitative and quantitative tables that banks should submit to their counterparties in order to gathered harmonized data to be more easily compared across different institutions.

On the other hand, also banks themselves need to enhance their internal management frameworks in regard to climate-related and environmental risks. More specifically, the most critical areas where they have to achieve significant enhancement are represented by their business strategy and their corporate governance.

As a concluding remark for the chapter, it is worth stressing that supervisory authorities and banks need to provide a joint effort to be able to overcome the data gap issue, and to make sure that the financial system as a whole can take advantage from a widespread integration of climate risks consideration.

The third and last chapter of this paper aims at going deeper in the analysis of the risk management methodologies that banks have at their disposal to actually quantify the impact of climate-related and environmental risks on their financing portfolios.

Through the study of a document published in January 2023 by the ECB, the first part will outline the main statistical indicators that are needed by banks to perform risk quantification practices in the absence of actual data, and the methodologies implemented to develop such statistical indicators.

Then, an illustration of risk assessment practices is provided.

About physical risk, it has been taken as example a paper issued by Intesa Sanpaolo together with Prometeia, which is a consulting company specialized in providing advisory services on risk management practices. The analysis under consideration computes the impact of flooding risk on a bank's mortgage portfolio on houses located in Italy, where this kind of environmental hazard has been taken into consideration as it is one of the extreme weather events for which it is available a greatest amount of data. The study is characterized by the mapping of physical impact on mortgage-backed houses around three layers, that is *exposure identification*, *hazard measurement* and *vulnerability assessment.* The mapping of flooding risk is then translated into quantitative risk parameters, namely the *Probability of default* (PD) and *Loss-given default* (LGD) through the implementation of specific functions. Then, such risk parameters are projected into banks' dynamic financial statements, especially on balance sheets, to get the actual impact of flooding risk in terms of likely effective monetary losses.

For transition risk assessment instead, the matter is much more complicated. Currently there is not a shared risk assessment framework as data on GHGs emissions and EPCs of buildings are widely unavailable, and the use of proxies among different financial intermediaries is not enough harmonized. Therefore, the most useful thing that banks can do in this regard is to evaluate their exposure towards carbon-intensive counterparties and set portfolio alignment targets based on their ambitions. Furthermore, banks can also compare their portfolio alignment targets with GHGs emission trajectories provided by several scenarios published by supervisory authorities such as the World Energy Outlook (WEO). Still, the path to obtain an accurate quantification of transition risk is long and uncertain. In order to try to address this issue, financial intermediaries have increased the cooperation among themselves through the creation of the Net Zero Banking Alliance (NZBA) which, besides seeking to support the ecologic transition, has the main strategic objective to develop shared frameworks for the collection of accurate emission data.

In conclusion, it can be said that this paper aimed at providing an overview of the current state of the financial sector with respect to the management and assessment of risks posed by climate change. Latest evidence shows that over the last few years supervisory and regulatory bodies, alongside financial institution themselves, have begun a process to concretely assess the impacts that physical and transition risk can have on banks' operations, and in turn on the financial system as a whole. In order to avoid severe financial disruptions, banks need to evaluate these risks and concretely support the transition towards carbon neutrality.

The analysis provided shows that banks have made progresses in the management of such threats. Especially for what concerns physical risk, the whole system has at least laid the foundation for the development of common risk management frameworks. However, these enhancements are mainly related to the actual assessment of only a subset of hazards (such as windstorms and flooding), which implies that further progresses need to be done also in this specific area. Furthermore, significant blind spots persist instead on the actual evaluation of transition risk, mainly because it is still challenging to collect emission data to perform the needed analyses.

Thus, it is needed a combined effort by all the players operating in the financial system to collectively develop new methodologies for addressing the transition risk issue. The creation of the NZBA can be considered as a good example of cooperation among banks to address this problem.

However, this may not be sufficient. There is also urgent need by regulatory bodies to keep developing mandatory rules on the disclosure of emission by all players in the economy.

1. CLIMATE CHANGE AND ITS EFFECTS ON THE FINANCIAL SECTOR

The main purpose of this chapter is to provide an overview of the historical development of the supervision of climate change, both from an environmental and a financial perspective. It will trace the evolution of regulatory and supervisory frameworks and the development of responsible investments in the financial sector. Next, following a definition of the main climate risks which have an impact on financial players, this chapter will examine the key milestones that have shaped the current state of climate risk supervision in the financial sector and the key actors and organizations that have played a significant role in creating it. This includes Non-Governmental Organizations (NGOs), international organizations, prudential regulators and central banks.

1.1 Introduction on landmarks for the supervision of climate change

The climate change movement, or the effort to address and fight the impacts of human-caused climate change, can be traced back to the 1960s and 1970s. In those years, scientists began to raise concerns about the potential impacts of human activities, such as burning fossil fuels, on the Earth's climate.

The first significant early event was the United Nations Conference on the Human Environment in 1972, which was the first global conference to address environmental issues. The conference resulted in the creation of the United Nations Environment Programme (UNEP) and led to the development of several international agreements, among which the Basel, Rotterdam and Stockholm Conventions, which recognized the need to protect the environment for the benefit of present and future generations.

However, one of the most important events in the history of the climate change movement was the signing of the United Nations Framework Convention on Climate Change (UNFCCC), which was subscribed at the United Nations Conference on Environment and Development (UNCED), or Earth Summit, in Rio de Janeiro in 1992. This treaty, which was signed by 154 countries, established a framework for international cooperation to combat climate change by stabilizing greenhouse gas concentrations in the atmosphere, and marked the beginning of formal international efforts to address climate change. In fact, since the signing of the agreement, member countries were required to meet annually at the Conference of the Parties (COP) in order to discuss climate change matters and verify the effective achievement of targets. Therefore, through the COPs, the UNFCCC has set the foundation for the subsequent agreements and protocols.

The first significant landmark in the sequence of COPs was the signing of the Kyoto Protocol, in 1997. The agreement, which entered into force in 2005, set binding targets for the European Union

and the 37 countries[1] that fully participated in the first commitment for reducing greenhouse gas emissions. These reductions were required to be made between 2008 and 2012, and it was the first time that countries were legally bound to reduce emissions. Even if the agreement's success has often been questioned, it has been shown that the Kyoto Protocol has been successful in reducing GHGs emissions of the ratifying countries by about 7% below the emissions expected under a "No-Kyoto" scenario[2].

In December 2012, the Doha Amendment to the Kyoto Protocol was adopted for a second commitment period, lasting from 2013 to 2020. The amendment revised the targets to be achieved and was accepted, as of 2020, by 147 Parties.

Another conference which is worth mentioning is the COP15, which took place in Copenhagen in 2009. The COP15 was significant because it was the first time that countries were expected to agree on a treaty to address climate change that would include all countries, not just developed ones, as was the case with the Kyoto Protocol. Even if the COP15 did not result in a legally binding agreement, it was considered important because it raised awareness of the necessity of addressing climate change, and because it laid the foundations for the COP21 in Paris in 2015, which resulted in the Paris Agreement.

The Paris Agreement is considered to be the most important COP to date, as it was ratified by almost every country in the world and set a clear direction for the transition to a low-carbon future. This agreement will be analyzed later in this chapter, as it also had a major importance in developing and raising awareness towards sustainable finance techniques and responsible investments.

1.2 A brief history of responsible investments

The birth of the modern concept of responsible investing can be traced back to the 1970s, when investors started to use their investments to promote environmental and social values. Such practices began first by avoiding investments in companies that were involved in controversial activities, such as tobacco and weapons, and later in the 1990s by engaging and investing in companies that were considered to be environmentally and socially responsible.

Starting from the first years of the 21st century, several international authorities have published sets of principles and guidelines to be followed in order to further promote green investments. Such principles were directed and have been adopted not only by individual investors, but also by

[1] A peculiar fact was that the United States of America, one of the greatest contributors of GHGs emission, did not ratify the protocol. This has been one of the reasons for the limited success in achieving the emissions reduction goals

[2] Maamoun N. (May, 2019), *The Kyoto protocol: Empirical evidence of a hidden success*, Journal of Environmental Economics and Management

institutional investors and asset managers, making responsible investing an increasingly adopted practice.

1.2.1 ONU Principles for responsible investments (PRIs)

In the early 2005, the Nobel Peace Prize Winner Kofi Annan recognized the importance of the United Nations working more closely with the private sector, arguing that the social and environmental goals of the UN and the financial goals of business can be mutually supportive. Thus, he invited a 20-person group made of the world's largest institutional investors and asked them to join a process for the development of the Principles of Responsible Investments, which were launched at the New York Stock Exchange in 2006. This set of rules, developed in partnership with United Nations Environment Programme Finance Initiative (UNEP FI) and the United Nations Global Compact (UNGC), represented the first milestone in the process of integration of environmental and social matters into investment practices.

The 6 Principles for Responsible investments are listed below:

1) "We will incorporate ESG issues into investment analysis and decision-making processes."
2) "We will be active owners and incorporate ESG issues into our ownership policies and practices."
3) "We will seek appropriate disclosure on ESG issues by the entities in which we invest."
4) "We will promote acceptance and implementation of the Principles within the investment industry"
5) "We will work together to enhance our effectiveness in implementing the Principles."
6) "We will each report on our activities and progress towards implementing the Principles."[3]

As already introduced, the main objective of the PRIs is to make sure that sustainability matters are taken into consideration by financial players, and to support investors in integrating ESG (Environmental, Social, Governance) criteria in their investment valuation. The logic behind the Principles is that in order to ensure a constant value creation over the long term, the global financial system needs to be economically efficient and sustainable.

Even though the Principles are not legally binding, since their publishing the number of signatories has steadily increased. As shown by the graph reported below, as of April 2021 the initiative has reached more than 3500 signatories by financial players from more than 100 countries[4].

[3] UNPRI, What are the Principles for Responsible Investments?
[4] United Nations Environment Programme Finance Initiative (UNEP FI), *United Nations Global Compact (UNGC) (April, 2021), Principles for Responsible Investments – 2021 Report*, blueprinv.unpri.org

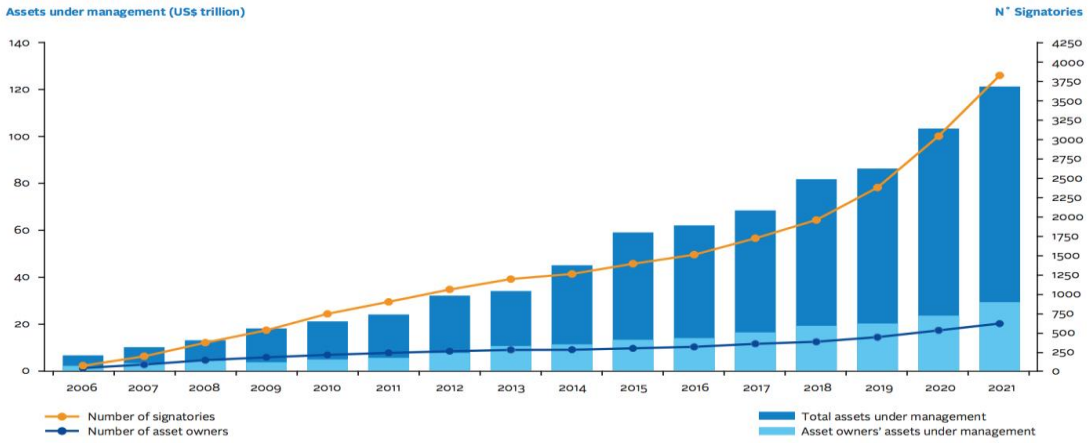

Figure 1[5]: Table showing the number of PRIs' signatories, the number of asset owners and the Assets under management (US$ trillion) from 2006 to April 2021

1.2.2 The European Forum for Responsible Investments (Eurosif)

The European Forum for Responsible Investments is a not-for-profit association established in 2005 with the aim of promoting sustainable and responsible investments (SRIs) for the benefit of investors, companies, and above all the society as a whole. It is a leading organization that conducts research and advocates for policies and regulations that support the development of SRIs. Furthermore, it provides a platform for networking and information sharing among its members and all the involved stakeholders.

In its 2012 Annual Report, the Eurosif identified seven leading ESG investment strategies which were made available to investors:

- *Exclusions:* an approach that excludes from the investment opportunities companies, sectors or countries involved in specific unethical activities such as tobacco, weapons, pornography and animal testing.
- *Best in class:* this approach involves investments in companies, sectors or countries which are considered *best in class* based on the analysis of several ESG criteria.
- *Sustainability-themed:* involves investments in companies or assets which have a strict link with the development of sustainability, or in thematic funds which focus on specific themes related to ESG matters.
- *ESG integration:* refers to the inclusion of ESG factors alongside financial considerations in the assessment of an investment opportunity. The main focus of this investment strategy is on the potential impact of ESG matters on the company financials.
- *Norm-based screening:* refers to the screening of investments based on the compliance of companies or assets with international norms covering ESG factors.

[5] Source: United Nations Environment Programme Finance Initiative (UNEP FI), *United Nations Global Compact (UNGC) (April, 2021), Principles for Responsible Investments – 2021 Report*, blueprinty.unpri.org

- *Engagement and voting:* approach that involves engagement through voting of shares with companies based on ESG matters.
- *Impact investing:* it is probably the most effective way to have an impact on financial sustainability. Refers to investments made into assets or companies seeking for a positive environmental and social impact besides a financial return.

1.2.3 2030 Agenda and Sustainable Development Goals (SDGs)

The 2030 Agenda for Sustainable Development is a plan of action adopted by all the 193 United Nations Member States in 2015. The Agenda aims to achieve several targets, which are mainly directed towards ending poverty, protecting the planet and ensuring that all people will be able to enjoy peace and prosperity by 2030. The Agenda includes 17 Sustainable Development Goals (SDGs) and 169 targets that member states are expected to achieve.

The SDGs are intended to be universal and integrated, meaning that they apply to all countries and all segments of society, and that they take into account the economic, social, and environmental dimensions of sustainable development. They are designed to be a plan to achieve a better and more sustainable future for all people, specifically the most vulnerable and marginalized, by addressing the underlying causes of poverty and the universal need for development that works for all people.

Figure 2[6]: The 17 Sustainable Development Goals (SDGs)

1.2.4 Paris Agreement

The Paris Agreement is an international treaty adopted in the context of the COPs by the UNFCCC in 2015. As introduced in the previous paragraph, it is widely considered as the most important agreement taken during all the COPs. The main goal of the Paris Agreement is to limit the

[6] Source: ISTAT, *Quali sono i 17 Sustainable Development Goals*

increase in global average temperature to well below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5 degrees Celsius. What makes this treaty unique with respect to the previous UNFCCC treaties is that the Paris Agreement constitutes a legally binding agreement, and it was adopted by the vast majority of world countries, on top of the European Union. In 2015 indeed 196 parties have joined the agreement, while as of January 2023 the countries who ratified the treaty were 194[7][8].

Under the Paris Agreement, each country is required to put in place integrated national energy and climate plans (NECPs) for the period 2021-2030, in order to concretely reduce carbon emissions. Furthermore, the treaty establishes a framework for countries to regularly report on their emissions and their progress towards emissions reduction targets, which are known as Nationally Determined Contributions (NDCs). The agreement also establishes a mechanism for countries to regularly update their NDCs[9], with the aim of increasing their ambition over time. On top of that, it also includes a mechanism to provide financial and technical assistance to developing countries to help them adapt to the impacts of climate change and to the transition to low-carbon economies, that is to reach their NCDs. This mechanism is known as the Green Climate Fund.

The Paris Agreement is strictly related to responsible investments since, being a legally binding agreement, it constitutes a strong incentive to identify and invest in companies and projects which are well positioned to help countries achieve their NDCs. Furthermore, it creates financial opportunities for companies and projects that are focused on clean energy, energy efficiency, and carbon capture and storage. In conclusion, it can be said that the Paris Agreement outlines a framework for addressing climate change and promoting sustainable investments that are necessary in the context of the transition towards a low-carbon economy.

1.2.5 2018 IPCC Report

Another organization which is worth describing within this paragraph is the Intergovernmental Panel on Climate Change (IPCC). The IPCC is an international body that was established in 1988 by the World Metereological Organization (WMO) and the already cited UNEP. It has the main goal of providing scientific information to policy-makers and the public about climate change and its impacts, and to provide guidance on the measures that can be taken to mitigate them.

[7] UN (2023), *The Paris Agreement*
[8] The USA ratified the Agreement in 2015, but they announced the withdrawal under the Trump administration in 2017. Then they officially rejoined the Paris Agreement in 2021 under the Biden administration.
[9] Among the top 4 GHGs emitters (China, USA, European Union, India), as of 2021 only the EU was on track to cut carbon emissions by 58% by 2030.

The report IPCC has published in 2018 states that if carbon emissions remained at current levels, in 10 years the average global temperature would rise by 0.2 degrees Celsius, reaching +1.3 degrees Celsius in 2032 and +1.5 degrees Celsius by 2040. Thus, it provided additional basis for countries to review and increase their emissions reduction targets every five years as required by the Paris Agreement.

The report highlights that limiting warming to 1.5 °C would require rapid and far-reaching transitions in land, energy, industry, buildings, transport, and cities. In order to achieve this limit, it would be required an immediate reduction of carbon emissions of 45% by 2030 and to reach net zero by around 2050.

1.2.6 The European Green Deal

The European Green Deal is the European Union's plan to become the world's first climate-neutral continent by 2050. It was published in 2019 and it is composed of a set of policies and initiatives which aim to make the EU's economy sustainable by turning climate and environmental challenges into opportunities across all policy areas and making the transition just and inclusive for all.

The EU Green Deal has proposed several measures that should address every aspect of environmental and climate change challenges. The objectives being sought are displayed in the graph below:

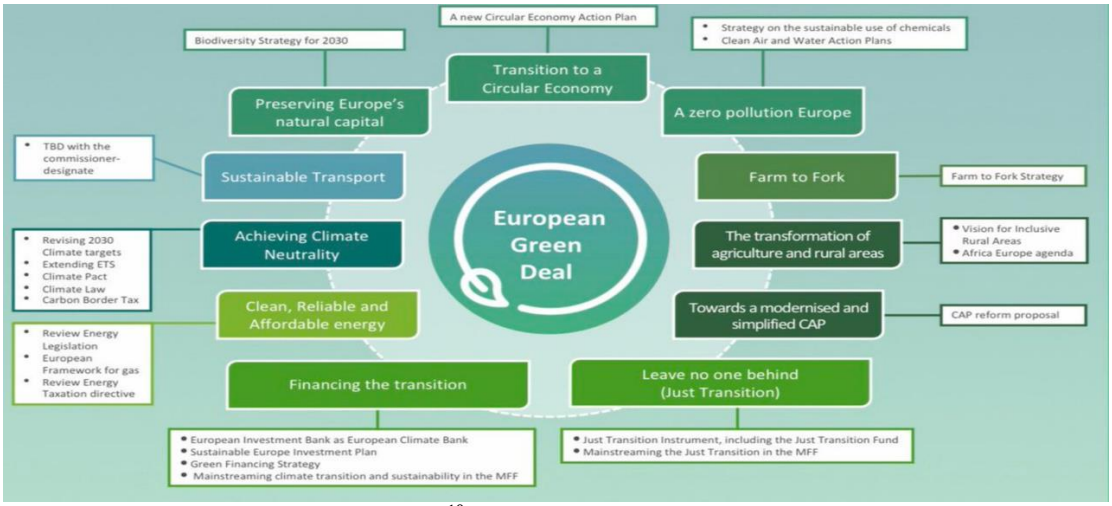

Figure 3[10]: The EU Green Deal goals

With specific regard to the financial sector, the EU Green Deal's main proposals were:

[10]Source: SUSEET (February, 2020), Climate change and the EU strategy: the European Green Deal

- Establishing European standards for sustainable investments: the EU Green Deal enhanced the role of EU Taxonomy by proposing a classification system for sustainable activities to ensure that investors can make informed decisions.
- Increasing the disclosure of sustainability risks in financial reports, with the aim to provide investors with more information on how companies and investment funds are managing their sustainability risks.

Thus, the EU Green Deal has laid the foundations for the creation of subsequent mechanism of classification and control of sustainable activities such as the EU Taxonomy, which will be analyzed more in depth later in this chapter.

1.3 Climate & Environmental risks for the banking industry

The previous paragraph introduced the main organizations involved in the fight against climate change, and the main milestones and sets of regulations that shaped the way and laid to the expansion of sustainable and responsible investments.

From now on, the main focus of this paper will be to analyze the close relationship between climate change and the financial sector. In fact, climate change poses serious threats not only to our planet and the society as a whole in terms of environmental health, but can also lead to economic and financial markets disruptions. This can happen since global warming has a negative impact over all layers of the society, including banks but also companies which are indebted to banks and therefore may have a significant impact over banks' balance sheets. In this context, the key point is that every time a company faces a risk, this same risk is transferred to the banks who have given credit to that certain company.

Climate and environmental risks have therefore to be integrated into the credit risk areas of financial institutions.

We have witnessed over the last two decades how dangerous can be the consequences of a banking failure[11]. That is why all financial players need to properly take into consideration the risks related to climate change and its direct effects.

The main climate and environmental risks can be divided into two main categories:

- ***Physical risk***: refers to the impacts of climate change-related events on physical assets, infrastructure, and people. Physical risk can in turn be divided into *acute* and *chronic physical risk*, where the former refers to event-related impact of extreme weather events, and the latter

[11] Banking failures have several downsides on the local economy, among which higher poverty rates, lower employment, lower income and compensation growth. In this context, global warming has put a question mark over the health status and the monitoring strategies of risks by banks.

is related to the long-term impact of climate change patterns, such as the rise in sea level or the change in average annual rainfall.

– ***Transition risk***: refers to the risks associated with the transition to a low-carbon economy, such as changes in regulations and policies, shifts in market demand, and the changes in technologies and practices which can lead to the creation of stranded assets. Also transition risk can be broken down into more specific risk areas, as it will be shown by the following figure. Among those risks, the most significant are *liability* (or *policy and legal*) risk, *reputational* risk, *technology* risk and *market* risk. Liability risk refers to the potential financial losses that a company may incur as a result of legal actions taken against them for their role in causing or contributing to climate change. Reputational risk refers to the potential damage to a company's reputation as a result of its actions or perceived actions in relation to climate change. This can include negative public perception, loss of customers, damage to brand image, and decreased investor confidence. Technology and market risks refer instead to the possible breakthrough of new technologies or the shift in market preferences towards alternative and more sustainable investments, which can have a negative financial impact on the concerned companies.

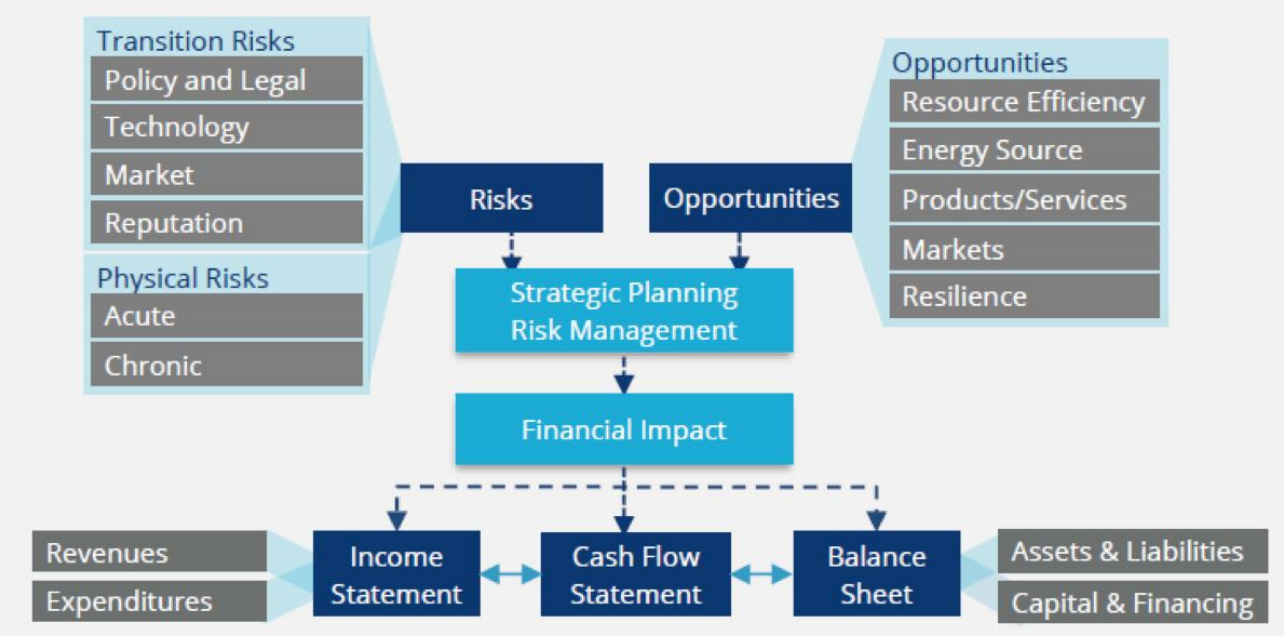

Figure 4[12]: Climate-related risks, opportunities and financial impact

As it can also be inferred by figure 4, climate change considerations come not only with risks, but also with some associated opportunities. These opportunities are mainly directed to an enhancement

[12] Source: TCFD 2017 Final report

of efficiency for what concerns the use of resources (such as raw material, water, and waste management) and especially to a shift in the energy sources towards renewables.

Physical and transition risk are the two major risks that will be taken into consideration throughout the risk analysis in this paper since they have the potential to cause significant economic and social impacts even in the short term. Furthermore, they can both have an impact on each other and can exacerbate each other in some cases. For instance, physical risks such as extreme weather events can increase the urgency of a transition towards a low-carbon economy, as it highlights the need for more resilient and sustainable infrastructure. Similarly, transition risks such as changes in regulations can lead to the creation of stranded assets, which can increase physical risks as it can lead to a lack of investment in infrastructure and maintenance. That is why they need to be considered together.

This paragraph will follow-up with a more accurate definition and description of physical and transition risks, shedding more light on the relationship between these risks and the banking sector.

1.3.1 Physical Risk

As already introduced, physical risks refer to the direct and indirect impacts of climate change on assets, such as natural disasters or sea-level rise. These risks can lead to financial losses through damage to property and infrastructure, as well as increased insurance costs.

The physical risk can be split over two main categories:

- Acute physical risk: refers to the risks arising from event-driven impacts, such as floods, drought, cyclones, etc. Such risks are difficult to be forecasted.
- Chronic physical risk: refers to medium-long term changes in the weather patterns which can have an impact on physical assets, such as rise in sea level or chronic heatwaves.

Both of these categories of risk can have a direct impact on bank's physical assets such as offices or branches, and an indirect impact by affecting physical assets of the banks' borrowers. More precisely, banks' assets at risk represent mainly mortgages portfolios and loans portfolio to the corporate sector.

Banks have large portfolios of mortgages that are exposed to physical risks, as they are vulnerable to sea level rise or extreme weather events. If the houses backed by mortgage securities are damaged or destroyed, banks may not be able to recover the full value of their loans, which can lead to financial losses.

Similarly, physical risks can also lead to losses coming by default on loans to the corporate sector. For example, if a natural disaster damages or destroys critical infrastructures, such as power plants or

roads, it can disrupt economic activity and lead to a decline in creditworthiness for borrowers, which can lead to defaults on loans and other financial losses for banks.

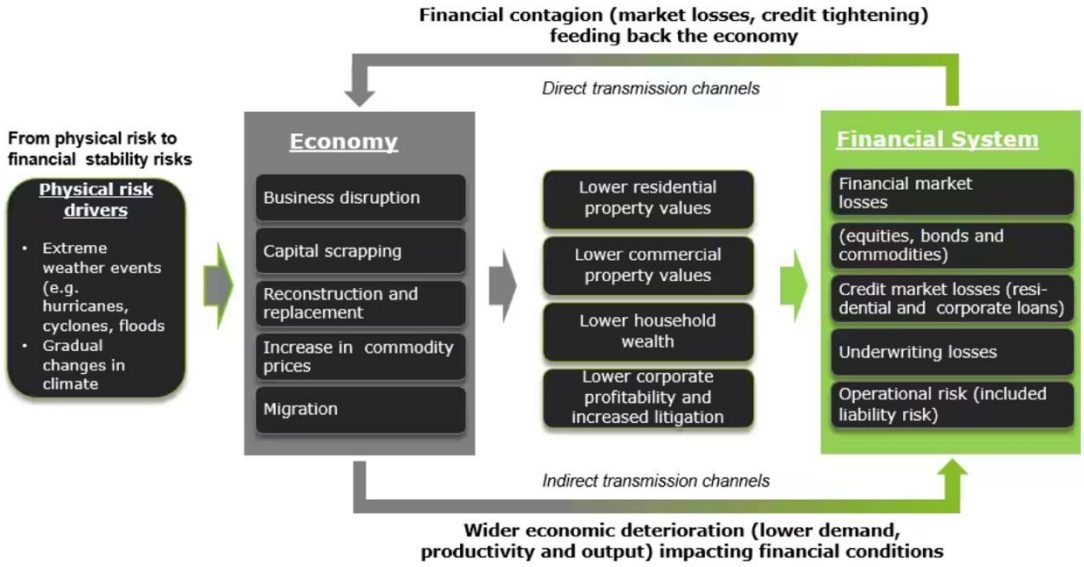

Figure 4[13]: The relation between physical risk and the financial system

The graph above provides supplemental evidence to what has been said before in this paragraph. As global warming has become a concrete threat for the financial system, banks are increasingly seeking for proper climate risk-assessment methods in order to keep their portfolios balanced.

1.3.2 Transition risk

Transition risks refer instead to the potential financial risks associated with the transition to a low-carbon economy. This includes risks related to changes in policy, technology, and market conditions that are aimed at reducing GHGs emissions and mitigating climate change.

As we move towards a net-zero economy, changes in policies and the emergence of new technologies are causing many polluting assets to rapidly lose their value. It is the case of stranded assets, which is one of the most common phenomena relative to transition risk. However, the same rule applies also to companies operating in polluting sectors, such as energy production and extraction of raw materials. Such sectors will be likely harmed by the transition towards a greener economy.

As it was with the physical risk, many banks are largely exposed towards companies which in the short-medium term may face a reduction in the value of their assets because of climate matters, and in turn a reduction in their cash flows.

Those financial impacts may lead to the possibility of companies not to repay their loans, causing significant damage also to the lending banks' balance sheets.

[13] Source: NGFS 2019 Report

For instance, if a bank has lent money to a company which is highly dependent on fossil fuels, and the company's creditworthiness declines as a result of a decrease in demand for fossil fuels, the lending bank may suffer financial losses as a result of the increase in credit risk.

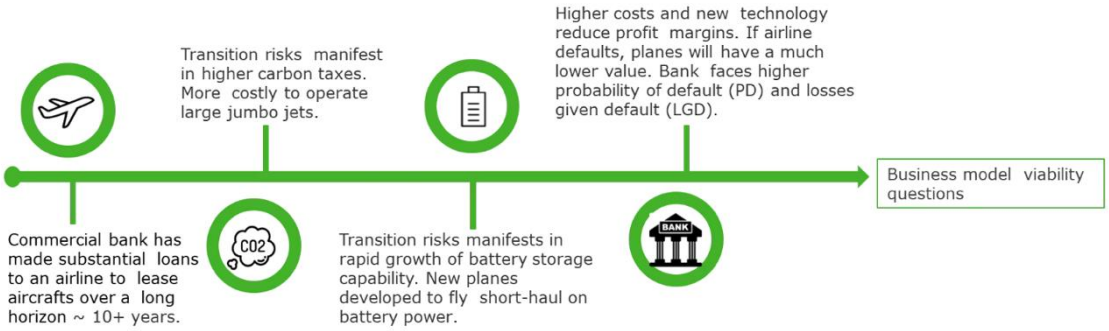

Figure 5[14]: Example of potential impacts of transition risk on a bank

Figure 5 provides an additional example of the transition risk arising from a loan made to a previously unsustainable company.

Being successful in the valuation of climate and environmental risks is not an easy task for banks, since it is very challenging to fairly quantify them. The next chapter will analyze more in depth the challenges, opportunities and possible areas of improvement that banks are facing in order to properly integrate these threats into their credit risk assessment systems.

1.4 International regulatory and supervisory initiatives for the corporate and the financial sector

The analysis of climate and environmental risks should have clarified the relationship between climate change and the stability of the financial sector.

The following paragraph will provide an overview of the main supervisory and regulatory initiatives that have been taken to address climate risk in the financial sector, and will examine the actions that financial regulators and supervisors have taken to ensure that the financial sector is resilient to the impacts of climate change.

1.4.1 The Task-Force on Climate-related financial Disclosure (TCFD)

The Task Force on Climate-related financial Disclosure is an organization established by the Financial Stability Board[15] (FSB) with the goal of developing a set of recommendations for voluntary

[14] Source: Deloitte (January, 2020), *Financial risks stemming from climate change: "Challenging the degree of resilience into a constantly changing environment*

[15] The FSB is an international organization which has the goal of monitoring and making recommendations about the global financial system. It was established in 2009

climate-related financial disclosures to be used by companies for providing information to investors, lenders, insurers, and other stakeholders.

Starting from the assumption that transparency is fundamental for financial markets to work properly, the TCFD was created in order to remedy the lack of information and the inconsistencies in disclosure procedures about climate change matters in financial markets, which can lead to a mispricing of assets and to a misallocation of capital.

In June 2017, the organization published its final report containing recommendations directed to any company which may interested in improving its transparency.

The TCFD's main recommendations are focused on providing information that would help investors, lenders, and insurers to understand a company's exposure to climate-related risks and opportunities, and to assess the potential impact of those risks and opportunities on the company's financial performance.

The recommendations are designed to be useful for a wide range of companies, regardless of their size, sector, or location. Furthermore, they encourage companies to disclose their climate-related financial disclosure in their mainstream (annual) financial filings. Information needs to be published in compliance with other existing disclosure frameworks, such as the International Financial Reporting Standards (IFRS) and the Sustainability Accounting Standards Board (SASB), in order to ensure consistency and comparability of information.

The core recommendation of the TCFD is to provide climate-related financial disclosure along four main areas:

1) ***Governance***: to provide information on how a company's board of directors oversees climate-related risks and opportunities, including the roles and responsibilities of management.
2) ***Strategy***: to provide information on how a company's strategy takes into account the potential impacts of climate-related risks and opportunities, including how the company is positioning itself to benefit from opportunities and manage risks.
3) ***Risk management***: to provide information on how a company identifies, assesses, and manages climate-related risks, including the potential impacts of physical risks, such as extreme weather events, and transition risks, such as changes in regulations or market conditions.
4) ***Metrics and targets***: to provide information on how a company measures and tracks its GHGs emissions, as well as its performance against emissions reduction targets.

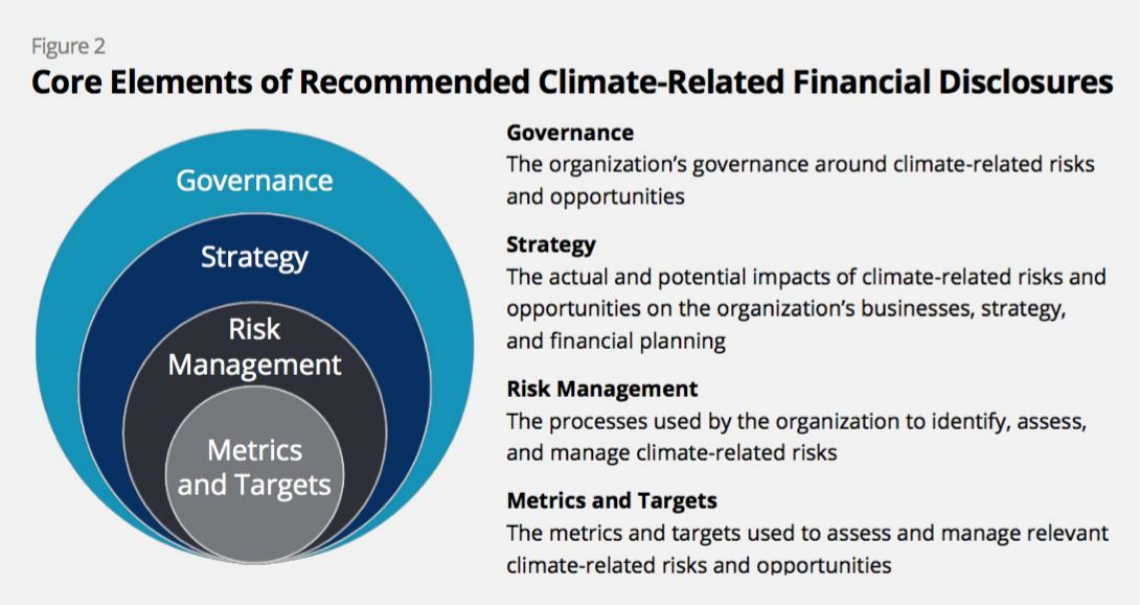

Figure 6[16]: The core elements of Recommended Climate-Related Financial Disclosures

Another important framework proposed by the TCFD is the use of scenario analysis as a tool for assess companies' climate risk and opportunities. This practice set the basis for the work of the Network for Greening the Financial System (NGFS), which explained more in depth how to use scenario analysis to asses and provide information on how companies are positioned to benefit from opportunities and manage risks in different climate-related scenarios.

Even though the recommendations are voluntary, they are widely recognized as a benchmark for best practices in climate-related financial disclosures. As of October 2022, the recommendations are supported by over 3800 organizations, among which over 1500 financial institutions[17].

1.4.2 The Network for Greening the Financial System (NGFS)

The Network for Greening the Financial System (NGFS) is an international group of central banks and supervisors that was established in 2017 to enhance the role of the financial sector in addressing climate change. Participating players are willing, on a voluntary basis, to share best practices and to promote mainstream financing for the transition towards a sustainable economy in order to help the financial industry strengthen its ability to manage climate and environmental risks.

As the TCFD, also the NGFS aims at providing recommendations that could help address climate-related issues. However, while the TCFD recommendation were directed to both companies and financial institutions, NGFS recommendations are mainly headed towards banks and central banks.

[16] Source: TCFD 2017 Final report

[17] FSB (October, 2022), *2022 TCFD Status Report: Task Force on Climate-related Financial Disclosures*

In May and June 2020, the NGFS has published two guides that were widely appreciated and used as landmarks for the management of climate risks by financial institutions.

The first one, which was released in May 2020, makes five recommendations to central banks and supervisory authorities on the integration of climate-related and environmental risks into their operations. The five recommendations are:

1) "Supervisors are recommended to determine how climate-related and environmental risks transmit to the economies and financial sectors in their jurisdictions and identify how these risks are likely to be material for the supervised entities."
2) "Develop a clear strategy, establish an internal organization and allocate adequate resources to address climate-related and environmental risks."
3) "Identify the exposures of supervised entities that are vulnerable to climate-related and environmental risks and assess the potential losses should these risks materialize."
4) "Set supervisory expectations to create transparency for financial institutions in relation to the supervisors' understanding of a prudent approach to climate-related and environmental risks"
5) "Ensure adequate management of climate-related and environmental risks by financial institutions and take mitigating action where appropriate."[18]

These five recommendations set the basilar framework for financial players to adequately manage and incorporate this relatively new source of risk. In this guide, the NGFS also introduced the need for financial institutions to carry out scenario analysis in order to capture the magnitude of climate-related and environmental risks.

In the second guide, which was published in June 2020, the NGFS provides a much more specific framework on how to concretely use scenario analysis. Being so precise, this guide is arguably the most useful for the financial players involved.

The guide provides a four-steps approach to scenario analysis[19]:

1) *Identify objectives and exposures*: scenario analysis can have several functions, such as stress testing financial firms and the financial system, or analyze structural changes to the economy risks to central banks' portfolios.
2) *Choose climate scenario*: the NGFS initially published three different reference scenarios based on three difference paths towards a lower-carbon economy. The three scenario will be analyzed more in depth later in this paragraph, and currently represent a widespread technique for the assessment of climate risk by banks and financial institutions.

[18] NGFS (May, 2020), Guide for supervisors
[19] NGFS (June, 2020), Guide to climate scenario analysis

3) *Assess economic and financial impacts*: climate scenario analysis can be useful for central banks and supervisory authorities because it provides the impact of climate change on a wide range of financial or macroeconomic variables, such as unemployment rate, GDP and inflation.
4) *Communicating and using the results*: results of scenario analysis can be useful to increase awareness or to develop subsequent follow-up actions to encourage banks to integrate climate-related and environmental risks into their risk management practices.

On top of the approach to properly carry out climate scenario analysis, as introduced on step 2, the NGFS also provided three reference scenarios whose main difference is the timing of implementation of policies to slow-down global warming.

The three NGFS reference scenario are namely the *orderly transition* scenario, the *disorderly transition* scenario and the "*Hot house world*" scenario.

- The orderly scenario assumes that immediate action is taken to be consistent with the targets set by the Paris Agreement. Thus provides for an immediate reduction in emissions.
- The disorderly transition scenario assumes that late actions are taken in order to be consistent with the Paris Agreement. Thus it provides for a quicker transition starting from 2030, which cause an increase of physical risk until 2030 and also of transition risk because of the more abrupt transition.
- The Hot house world scenario assumes that no further action is taken to tackle climate change. Thus, only current policies are implemented, leading to a high increase in temperatures and also on physical and transition risk.

The three scenarios are displayed in the graph below.

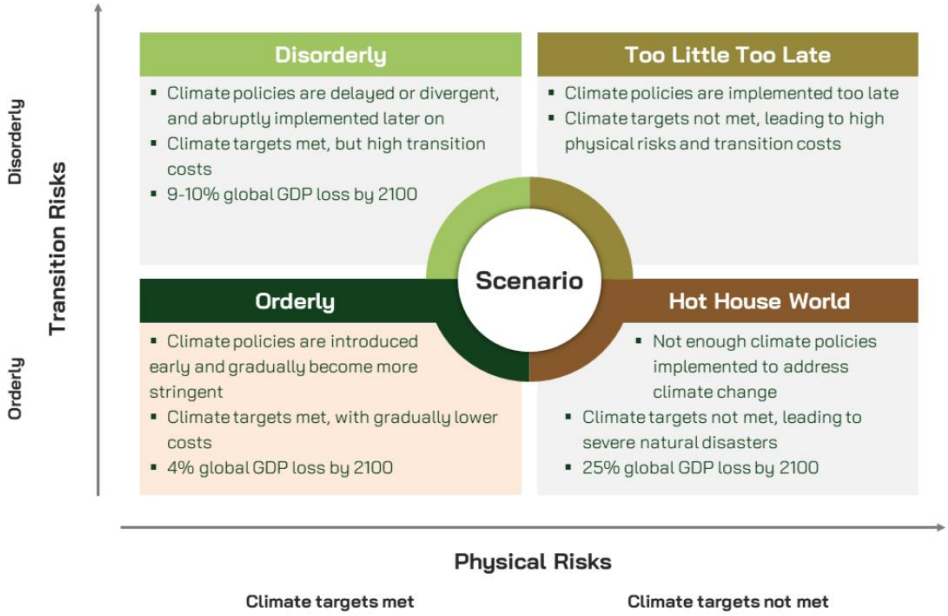

Figure 7[20]: The NGFS Reference scenarios

It is worth noticing, also with the help of figure 7, the relationship between the physical and the transition risks. Clearly the only scenario that keeps both of them low is the orderly transition, where physical risk is forecasted to be relatively low because of a stabilization of temperatures, and transition risk is low since the transition towards a low-carbon economy is gradual.

On the contrary, even though a disorderly transition succeeds in meeting the climate change targets, it causes high transition risks because of the sudden and unexpected transition. For the Hot house world instead, the transition risk is minimal since basically there will be no transition towards a lower-carbon economy, but the physical risk related to extreme weather events and rise in sea levels threatens to be incredibly high and economically unsustainable.

Following the success in the adoption of the three reference climate-related scenario analyses, the NGFS has developed 6 more precise scenario analyses, still in the context of the previous reference scenarios. These new scenarios share similar socio-economic assumptions, and are designed to explore in more specific cases the assessment of physical and transition risk.

[20] Source: NGFS (June, 2020), Guide to climate scenario analysis

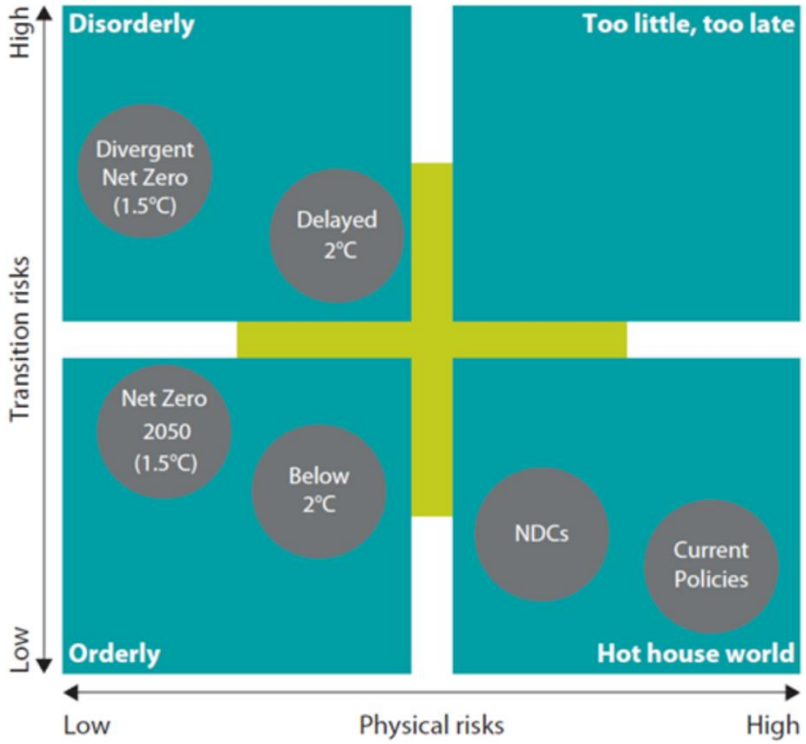

Figure 8[21]: The 6 NGFS scenario

As shown in figure 8, the six new scenarios are collocated within the three reference scenarios.

Within the orderly transition context, the NGFS has developed the *Net Zero 2050* and the *Below 2 degrees Celsius* scenarios. *Net Zero 2050* limits global warming to 1.5 degrees Celsius above pre industrial levels through the use of more stringent policies, while *Below 2 degrees Celsius* scenario leads to a 67%[22] chance of limiting global warming through the implementation of more gradual policies. It is to be noted that, because of more stringent policies, the *Net Zero 2050* scenario shows a higher level of transition risk with respect to the *Below 2 degrees Celsius* scenario.

Under the disorderly transition scenario, it can be found the *Divergent Net Zero* scenario and the *Delayed 2 degrees Celsius* scenario. Also in this case, the former shows a lower physical risk and a higher transition risk with respect to the latter. However, belonging to the disorderly transition scenario, they both represent higher transition costs and risk with respect to the *Net Zero 2050* and the *Below 2 degrees Celsius* scenario.

Last, the Hot house world scenario have been divided into the *NDCs* and the *Current Policies* scenarios. The first one assumes that the moderate climate ambitions reflected in the conditional NDCs will continue over the next century, leading to an increased temperature of 2.6 degrees Celsius by the end of the 21st century. The *Current Policies* scenario instead assumes that no further policy

[21] Source: ECB (November, 2020), From "orderly transition" to "hot house world" – how climate scenarios can facilitate action
[22] NGFS, *scenario portal*

is implemented, leading to a forecasted increase of 3 degrees Celsius with respect to the pre-industrial times. Even in this case, the implementation of environmental policies, even though very mild, lead to an increase in transition risk.

The following figure will provide additional information on the actual impact of each scenario on the main risk types and their related main characteristics.

		Physical risk	Transition risk			
Category	Scenario	Policy ambition	Policy reaction	Technology change	Carbon dioxide removal	Regional policy variation
Orderly	Net Zero 2050	1.4°C	Immediate and smooth	Fast change	Medium-high use	Medium variation
	Below 2°C	1.6°C	Immediate and smooth	Moderate change	Medium-high use	Low variation
Disorderly	Divergent Net Zero	1.4°C	Immediate but divergent across sectors	Fast change	Low-medium use	Medium variation
	Delayed Transition	1.6 °C	Delayed	Slow / Fast change	Low-medium use	High variation
Hot house world	Nationally Determined Contributions (NDCs)	2.6°C	NDCs	Slow change	Low-medium use	Medium variation
	Current Policies	3°C +	Non-currente policies	Slow change	Low use	Low variation

Colour coding indicates whether the characteristic makes the scenario more or less severe from a macro-financial risk perspective

Lower risk
Moderate risk
Higher risk

Figure 10[23]: Scenarios effect on risk indicators and characteristics

1.4.3 Basel Committee (BCBS) and the 3 Pillars framework

The Basel Committee on Banking Supervision (BCBS) is an international standard-setting body for banking supervision. It was established in 1974 by the central bank governors of the Group of Ten (G10) countries, and it is now made up of 45 institutions and representatives from central banks and regulatory authorities from 28 jurisdictions.[24]

The Basel Committee has not been created ad-hoc for addressing climate-related and environmental issues, as it was the case for the TCFD and the NGFS. Rather, it has always worked for the enhancement of financial stability through the improvement of banking supervisory matters worldwide, and it serves as a congress for strengthening cooperation between member countries on banking supervision.

However, the frameworks it has developed for banking regulation is to be applied also with regard to the climate risks for the financial sector.

The BCBS has published several report since its foundations, among which the most relevant are the *Concordat*[25], the *Basel Capital Accord* or *Basel I*[26], and the *Basel II*, which presented a revised

[23] NGFS, *scenario portal*
[24] BIS, *History of the Basel Committee*
[25] Issued in 1975, the Concordat set out the main principles for sharing supervisory responsibilities among host and parent, for bank's foreign branches
[26] Issued in July 1988, the Basel I stated that banks needed to keep a minimum ratio of capital to risk-weighted assets of 8% by the end on 1992

framework for banking supervision and comprised the three Pillars framework of banking supervision.

Then, the BCBS issued in the end of 2010 the *Basel III* in order to respond to the 20008 financial crisis. The *Basel III* is currently the reference framework for banking supervision, and represents an improved version of the *Basel II* capital framework. The current reference framework is based around the compliance with an enhanced version of the 3 pillars which were developed in *Basel II:*

1) The first pillar is the minimum capital requirement, which specifies the minimum amount of capital that banks must hold in order to cover potential losses from credit, market, and operational risks. It sought to develop the standardized rules set out in *Basel I* in 1988.
2) The second pillar is the supervisory review process, which involves ongoing monitoring and assessment of a bank's risk management and governance processes by the supervisor. This includes assessing the bank's risk management systems, internal controls, and the quality of its management team.
3) The third pillar is the market discipline, which is intended to increase transparency and accountability by requiring banks to disclose information on their risk exposures, capital adequacy, and other important financial information. This information is intended to be used by market participants, such as investors and depositors, to make informed decisions about a bank's creditworthiness.

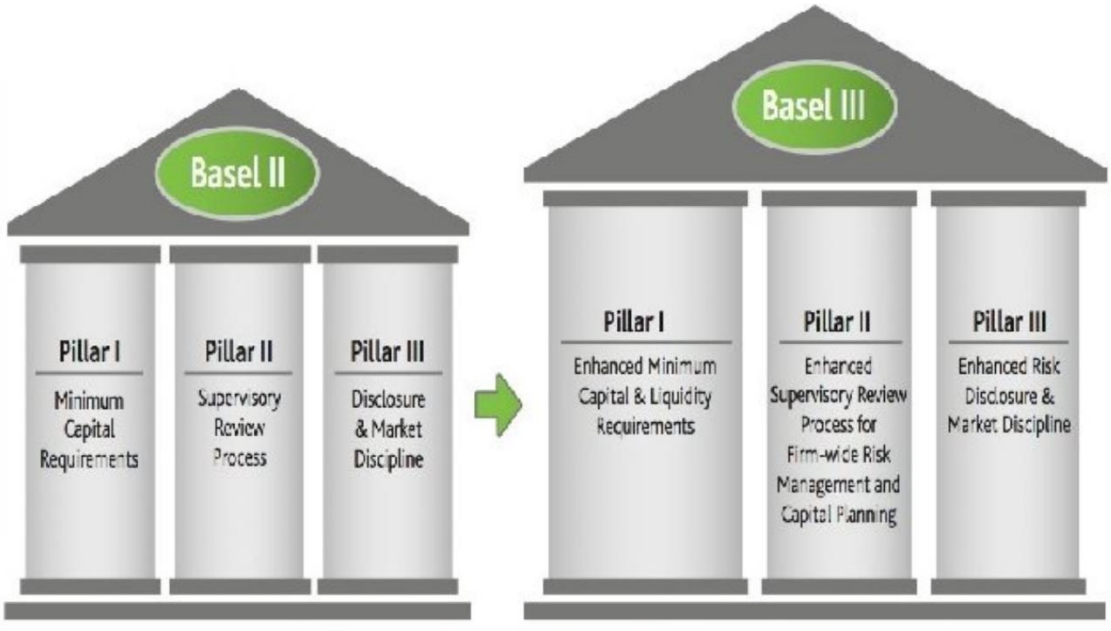

Figure 9[27]: From Basel II to Basel III 3 Pillars framework

[27] Source: Standard Chartered, *Basel Accord by Daren Warner Chief Financial Officer Basel*

Coming back to the context of climate and environmental risk supervision, it is clear that the compliance with the three pillars is fundamental for banks to be shielded against the arising impacts related to climate risk.

In this regard, the Basel Committee has published in June 2022 its principles for effective management and supervision of climate-related financial risks. The paper is structured around 18 principles that bank should understand and enact. The principles and recommendations in part incorporate the ones published by the TCFD and the NGFS such as the disclosure of climate-related financial information and the implementation of scenario analysis to forecast the future climate-related financial landscape. Apart from that, the principles focus on the supervision by banks on their corporate governance, internal control frameworks, capital and liquidity adequacy, and risk management practices to ensure that climate change do not excessively impact the banks' credit, market, liquidity and operational risk management areas.

1.4.4 The European Commission Action Plan

The European Commission Action Plan on Financing Sustainable Growth was published in 2018 with the aim to mobilize investment in sustainable projects and to create a framework for integrating sustainability into the financial system. In order to do so, the EU Commission has developed ten key actions which can be divided over three main categories:

- *Fostering investments in sustainable projects:* this includes measures such as the EU Taxonomy Regulation and the Sustainable Finance Disclosure Regulation (SFDR), which aim to provide a common framework for the classification of sustainable investments, and to improve the quality and comparability of sustainability-related information for investors and other market participants. Both the EU Taxonomy and the SFDR will be analyzed more in depth over the next subparagraphs.

  Other techniques introduced by the EU Commission Action Plan include the creation of an EU Green Bond and of green labels for retail investment products.
- *Mainstream sustainability into risk management:* this category focuses on ensuring a better integration of sustainability in ratings and market research, and ensuring that asset managers have clear their duties with respect to sustainability matters. On top of that, in the context of the Action Plan, the EU Commission and the EU Parliament agreed to mandate the European Banking Authority (EBA) to identify the methodologies for integrating climate-related risks in the review performed by supervisors. Also the EBA guidelines will be analyzed later in this chapter.

- *Fostering transparency and long-termism:* the Commission has published its guidelines on the disclosure of climate-related financial information. Furthermore, the Commission recommended to attenuate short-termism in capital markets.

1.4.4.1 The EU Taxonomy

The EU Taxonomy is a classification system for sustainable activities developed by the EU Commission. It has the main objective of providing clarity to investors whether a certain investment can be considered sustainable or not, in order to promote responsible investments in the financial markets and preventing greenwashing.

The EU Taxonomy includes a set of standard definitions for sustainable activities focused on six environmental objectives, which are shown in the figure below:

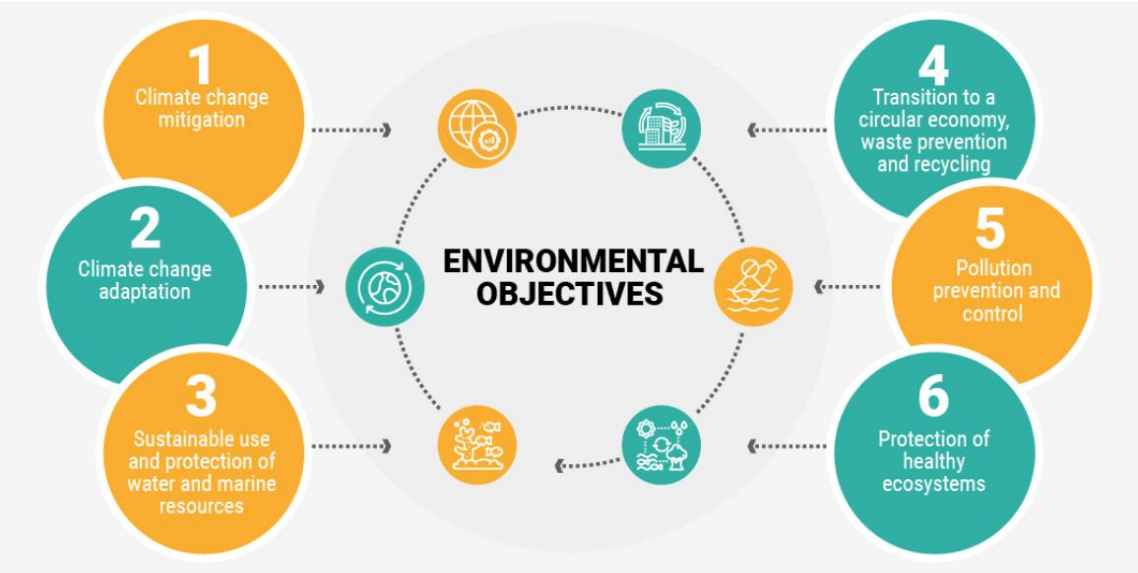

Figure 10[28]: EU Taxonomy 6 environmental objectives

The Taxonomy suggest sustainable investments in about 70 economic activities partitioned over 7 macro-sectors, which overall are responsible of the production of 93% of total emissions at European level.[29]

Thus, it seeks for green investments inside sectors that normally produce huge amounts of GHGs emissions. Namely these sectors are:

- Water, sewerage, waste, remediation
- Energy, gas, steam, air conditioning supply
- Agriculture and forestry

[28] Source: Morningstar, *EU Taxonomy solutions - Assess companies' alignment to the EU Taxonomy*
[29] Bloomberg Professional Services (January, 2021), *Applying the EU Taxonomy to your investments, how to start?*

- Buildings
- Transports
- Manufacturing
- ICT

In order for an economic activity to be eligible for the EU Taxonomy, whether it is a company or an investment, it has to comply with four different criteria:

1) It needs to make a substantive contribution to at least one environmental objective
2) It does not have to significantly harm any of the other objectives
3) It has to meet the minimum safeguards (such as the OECD guidelines on Multinational Enterprises and the UN Guiding Principles on Business and Human Rights)
4) It has to comply with quantitative and qualitative technical screening criteria

1.4.4.2 The Sustainable Finance Disclosure Regulation (SFDR)

The Sustainable Finance Disclosure Regulation (SFDR) is a regulation proposed by the EU Commission in the context of the EU Action Plan for sustainable finance. The regulation, which came into effect in March 2021, requires financial market participants to disclose information on the sustainability risks and opportunities they take into account when providing investment advice or issuing a prospectus. The SFDR applies to all financial market participants, including investment firms, credit institutions, insurances and alternative investment fund managers. That is, to any kind of asset manager operating in the financial market.

The SFDR is characterized by two main requirements:

1) The first one is the pre-contractual (or prospectus) disclosure requirement, which applies to financial market participants when they are providing investment advice or issuing a prospectus. Under this requirement, financial market participants must disclose information on the sustainability risks they have considered and how they have taken those risks into account when providing investment advice or issuing a prospectus.
2) The second one is the product-level disclosure requirement, which applies to financial products and services. Under this requirement, financial institutions and product manufacturers must disclose information on the sustainability characteristics of their products, including the environmental or social characteristics of the product, the risks and opportunities related to those characteristics, and how those risks and opportunities have been taken into account in the product's strategy or investment policy.

The SFDR is therefore intended to increase transparency and accountability and to provide investors with the information they need to make informed investment decisions, and to encourage the development of sustainable finance.

Overall, the proposals and regulations issued by the EU Commission Action Plan for Sustainable Finance were aimed at strengthening the role of the financial sector in achieving a more sustainable economy under the social and environmental point of view.

1.4.5 The ECB Guide

Another fundamental framework for the proper supervision and management of climate-related and environmental risk has been provided by the ECB Guide, which was published in November 2020.

As it has been explained previously in the chapter, the financial sector plays a key role in the transition towards a circular economy characterized by low GHGs emissions. At European level, the ECB role is of critical importance in the context of transforming Europe in the first climate-neutral continent by 2050, as stated by the EU Green Deal. At the same time, the transition towards climate neutrality comes with great risks for the whole economic and financial sector. For the second year in a row[30], the ECB had classified climate-related and environmental risks among the greatest risks for the banking sector.

For this reason, it is crucial for banks and financial institutions to be able to implement a forward-looking and comprehensive approach in the management and internal control of such risks.

This is what the ECB Guide is about.

The Guide aims at providing suggestions to banks on the appropriate ways to manage climate-related and environmental risks through 13 supervisory expectations, which can be divided over 4 macro-areas:

1) ***Strategy****:* the ECB expects banks to fully comprehend the impacts of climate change in the markets where they operate, and to assess how climate risks may affect their strategy. This can be done through the implementation of scenario analysis and the valuation of some Key Performance Indexes (KPIs) such as the carbon footprint of their financed activities and the average energy efficiency class of their mortgages portfolios. Basically, banks are expected to set their strategic approach with respect to climate-related risks based on both KPIs and the outcomes of scenario analyses.

[30] As of 2020

2) ***Governance**:* banks are expected to integrate climate-related matters into their governance frameworks: More specifically, banks should set up a governance framework that assigns clear roles and responsibilities in regard to climate change matters. This goal can be achieved through a creation of a board level committee which is responsible of environmental issues. Furthermore, the governance framework should also include policies and procedures for identifying, assessing, managing, monitoring and reporting on climate risks.
3) ***Risk management:*** the ECB expects banks to take into consideration the risks arising from climate change over the short, medium and long term, and to properly integrate those risks in every area of their current risk management frameworks, also through the implementation of scenario analyses and stress tests. With regard to the credit risks, banks should consider the possible impact of climate change over all the phases of credit granting, and to properly monitor climate risks on their portfolios. Banks should also be able to develop frameworks to assess, at least on a qualitative basis, the climate- related and environmental risks. Climate risks should also be integrated into the risk management areas of operational risks, market risks and liquidity risks, in order to assess if climate risks can drive a decrease in the banks' cash flows.
4) ***Disclosure:*** the ECB recommends that financial institutions disclose information on the risks and opportunities associated with climate change, and on the actions they are taking in order to manage those risks and opportunities. To do so, banks are expected to report on climate risks in the annual report being consistent with the TCFD recommendations, and to provide information on the bank's strategy and actions to manage climate risks.

1.4.6 The EBA guidelines

The last supervisory framework which will be analyzed over this chapter refers to the guidelines which have been published by the European Banking Authority (EBA) over several reports and discussion papers. Among these, the most relevant in this purpose are the "EBA Action plan on Sustainable Finance" published on December 2019, the "EBA Discussion paper on management and supervision of ESG risks for credit institutions and investment firms" published in October 2020, and the "EBA report on management and supervision of ESG risks for credit institutions and investment firms" published in June 2021.

Over the years, the European Banking Authority has received several mandates for providing a valuation on how to include ESG matters into the 3 Pillars framework for banking supervisions published by the BCBS. Specifically, this paragraph will focus on the integration of those factors on

the second Pillar, which refers to the Supervisory Review Process on risk management, by focusing on the enhancement of the resilience of financial institutions to the potential impact of ESG risks.

It is worth recalling that climate risks, or more broadly ESG risks, materialize through the already existent categories of risks for the financial sector, namely credit risk, operational and reputational risk, market risk and liquidity risk.

In order to ensure a proper management of such risks, the EBA recommended their incorporation into the areas of business strategies, internal governance frameworks and risk management frameworks. These recommendations are in line with the ones provided by the ECB in its Guide, thus they will not be further analyzed.

For what concerns instead the assessment of ESG risks, the EBA has published in its 2021 report three innovative techniques: the *portfolio alignment method*, *the risk framework method* and the *exposure method*.

- The portfolio alignment method is based on the assessment of how far a bank's portfolio is aligned with the agreed climate targets set by supervisory authorities. More specifically, this approach aims at assessing in what ways a bank needs to adjust its portfolio in order to be consistent with the Paris Agreement 2 degrees Celsius scenario provided by the NGFS. Therefore, it requires for an extensive use of scenario analysis in order to assess the current bank's position. By analyzing its position with respect to the global climate targets set, a bank should be able to measure how big is the impact of climate-related and environmental risks.
- The risk framework method, in contrast with the alignment method previously analyzed, does not analyze the portfolio position with respect to some targets. Rather, it analyzes the risks internally through the focus on the impact that climate change may have on the risk of the financial exposures. This outcome can be achieved by conducting two different types of analyses:
    1) Through *climate stress tests*, which consist of a specific type of scenario analysis that provides possible future paths of variables such as climate change variables and the related macro variables (e.g. GDP, inflation rate), financial variables (e.g. interest rates) and transition variables (e.g. carbon prices). The results of the climate stress test are then converted into financial risks attributes on the bank portfolio.
    2) Through *climate sensitivity analyses,* which assess the impact on a bank's portfolio risk attribute of a change in some variables such as a carbon tax or an increase in temperatures with its related effects.
- The last method proposed by EBA for assessing ESG risks is the exposure method, which is characterized by a thorough analysis on the performance of a bank's counterparties, such as

the indebted companies, in terms of ESG attributes. This method can be applied on individual counterparties and can be used as a systematic approach to gain insights on the composition of a bank's portfolio and on its ESG performance as a whole. This method focuses on all the three aspects of ESG matters, while the two previous methods are meant to assess mainly climate and environmental matters.

This paragraph aimed to provide an overview of the current supervisory and regulatory framework that characterize the banking regulation landscape with respect to climate change matters. As it will be shown over the next two chapter, being compliant with the current supervisory expectations and correctly implementing the recommendations issued by supervisory bodies is a very complicated task for banks and financial institutions.

The continuation of this paper will try to explain why it is so difficult to integrate climate and environmental matters into the internal management frameworks of banks, and will outline some remedies that could facilitate the implementation of correct practices on the context where banks and financial institutions operate.

2. EUROPEAN BANKING SECTOR SEEKING FOR BALANCE AND RESILIENCE

This chapter represents the central body of the paper as it aims at providing a detailed overview of the current state of the European banking sector with respect to the integration and management of climate-related and environmental risks. By analyzing how financial institutions have implemented the recommended practices developed by the supervisory bodies outlined in Chapter 1, it will be possible to define the state of the banking industry and define its main limitations, some possible improvements and the future path to be followed by banks in order to be shielded against climate risks and to concretely contribute to the transition towards carbon neutrality.

The chapter will start with the analysis of some of the latest reports published by the ECB that explain where banks stand with the management of climate-related and environmental risks. Following that analysis, it should be clear that the road to an appropriate risk integration is still a long one, since financial players are still missing some kind of guidelines and the harmonization process for such practices among different banks is still at an initial stage.

Hence, there will be provided some possible remedies and mitigation practices which should help address some of the unsolved issues in the process of integration of climate risks into the internal control frameworks of banks and the harmonization processes for information gathering and disclosure.

Last, after having deeply analyzed the current shape of the financial industry through its progresses and deficiencies, the chapter will display the future supervisory expectations of the ECB with respect to the supervised banks.

2.1 Latest evidence on EU banking industry

This paragraph will focus on the progresses that banks have made over the last few years in carrying out proper climate-risk assessment practices. Data on the current state of health of the banking sector has been gathered through the analysis of some reports issued by the ECB during the years 2020-2022 which aimed to provide a snapshot of the banks' current stress test capabilities, their exposure to climate risk, their scenario planning capabilities, and their materiality assessment of climate-related and environmental risks. Such papers include the ECB Report named "Walking the talk - Banks gearing up to manage risks from climate change and environmental degradation" and another ECB Paper named "Good practices for climate-related and environmental risk management". These paper are meant to support and integrate information onto the main body of this paragraph, which is the "ECB 2022 climate risk stress test".

2.1.1 The ECB 2022 climate risk stress test

As the main supervisory body (together with the EBA) of the banking sector, the ECB is required to perform annually a stress test on the supervised banks in order to assess their capabilities and the appropriateness in qualitative and quantitative terms of their internal risk management frameworks. The stress test that the ECB has conducted in 2022 on its supervised entities is the bottom-up climate risk stress test, where the analysis has been performed by gathering input data directly by the individual banks supervised. The ECB Paper aims not only at merely analyzing the quantitative results of the test, but also at providing some kind of insights on the qualitative aspects that banks have put in practice to integrate ESG risks into their governance, business strategy and risk management frameworks. By doing so, the ECB can therefore be able to assess whether the supervised banks climate-risk management processes are in line with the recommendations set out in the ECB Guide or not.

The climate stress test's main goal is to gain an understanding of the current banks' stress testing capabilities and their readiness with respect to the possible materializing of climate-related risks.

In order to do so, the ECB has gathered information directly from the supervised banks which provided a set a set of inputs based on the compliance with common methodologies and the implementation of a common set of scenarios and stress tests. The data submitted by banks have then been further examined by the ECB in order to ensure a proper comparability of results and consistency of outcomes.

The data gathering process was carried out by the ECB through the implementation of 3 main methodologies. Before going deep on these approaches, it is worth to provide some definitions of the key inputs sought by the ECB for ensuring an accurate execution of the banking-wide climate stress test. Such inputs and variables represent the key elements of most of the subsequent analyses, thus they will have significant importance over the continuation of the entire document.

2.1.1.1 Introduction on key input variables

In regard of carbon emissions, ECB requires banks to provide data on their financed GHGs so to assess their exposure to climate-related and environmental risks. Relevant input data sought can be split over three major categories of GHGs emissions:

- *Scope 1 emissions* refer to direct emissions from sources that are owned or controlled by the financed organization. Examples include emissions from fuel combustion in boilers or vehicles, and emissions from chemical production processes.

- *Scope 2 emissions* refer to the indirect emissions from the generation of purchased electricity, steam, heating, and cooling consumed by the financed organization. These emissions occur at power plants and other facilities that provide energy to the organization.
- *Scope 3 emissions* are all other indirect emissions that occur in the value chain of the organization, but are not included in Scope 2. Examples include emissions from the production of purchased goods and services, employee commuting, and waste disposal. Scope 3 emissions are typically the largest source of a company's greenhouse gas emissions and are considered the most challenging to measure and manage.[31]

The actual quantification of emissions provides a key indicator to assess the exposure of a certain entity towards climate-related and environmental risks and, more specifically, is strictly related to the transition risk for the companies financed by banks. It will be seen over the continuation of the chapter how complicated it is to quantify the exact value of GHGs emissions, especially scope 3 emissions, and how banks can operate to try to address this kind of issue.

Another relevant input for the assessment of transition risk is the Energy Performance Certificate (EPC) of the buildings belonging to financed companies, and mostly of houses backed by mortgage securities. Thus, whether the previously analyzed variables are significant for the assessment of transition risk with respect to banks' financing portfolios towards the corporate sector, the EPC rating class provides relevant insights for the assessment of transition risk related to banks' mortgages portfolios.

The following is a more detailed definition of the Energy Performance Certificates rating class:

- *The EPC rating class* is a measure of the energy efficiency of a building. It is determined by an energy assessment, which is conducted by a qualified assessor and results in a certificate that gives the building a rating on a scale of A (most efficient) to G (least efficient). The rating is based on factors such as the building's structure and fabric, heating and lighting systems, and hot water supply. The certificate also provides recommendations for how the building's energy efficiency can be improved. Furthermore, it is used to comply with the energy efficiency requirements of the building codes and regulations.[32]

It should be straightforward that if a bank holds a mortgage portfolio with an average low rating, let's say close to G rating class, it incurs a greater probability of being impacted by transitional policies which could cause a lower creditworthiness of mortgage holders. In other words, the lower the EPC rating of financed buildings, the higher the transition risk for financing banks.

[31] Deloitte, *Scope 1,2, and 3 emissions – What you need to know*
[32] Evergreen Energy, *EPC Ratings and Heat Pumps*

The last environmental variable related to climate risk which is worth analyzing is the carbon price:

- *Carbon Price* is an instrument which assigns a monetary value to carbon or any GHG emissions[33] and ties them to the source of those emissions in order to provide a concrete incentive in reducing them. The carbon price is based on the external costs that the underlying emissions cause, such as damages to crops and buildings as a result of flooding and drought, and health costs related to the occurrence of extreme heat events. Therefore, carbon price is a relevant input variable which is not only related to transition risk, as it allows GHGs emitters to decide whether to cut their emissions or to keep paying for them, but also to physical risk as the outbreak of extreme weather events leads to an increase in carbon price.[34]

Carbon price is relevant for the implementation of climate stress tests by banks since it can be used as a tool to assess the potential financial impact of different levels of carbon pricing on a bank's loan portfolio or investments. Banks can use the carbon price to estimate the potential loss of value of assets, such as fossil fuel reserves or power plants, that would result from stricter regulations or a shift towards low-carbon energy sources. Furthermore, the use of a carbon price can help banks to assess the potential risk of the arising of stranded assets and the impact of climate change on their investments.

For what concerns instead the gathering of input variables strictly related to the assessment of physical risks, the approach is not so much directed at analyzing the activities of the banks' counterparties and their environmental characteristics, such as the scope 1, 2, 3 emissions and their EPC rating class. Rather, the approach is more routed towards the segmentation of the territory in different cells, where each cell is characterized by a different probability of incurring damages from the occurrence of extreme climate-related events. Hence, after having split the territory over difference segments, the analysis will follow with a distribution among the cells identified of the main offices of the financed entities (for what concerns the financial sector) and the aggregation of houses backed by the bank-issued mortgage-securities (for what concerns banks' real estate portfolios).[35]

It is not always easy to determine whether a certain office or branch which is located in a certain cell can be considered as the main office or not. Usually, to address this kind of issue, banks or any supervisory authority will check at the number of employees for every office to check which one could be the main production site. Even in the case where the aforementioned issue can be addressed,

[33] Usually in the form of a price for every ton of carbon emission produced

[34] The world Bank Group, *Carbon Pricing Dashboard*

[35] Sources: ECB, Statistics Committee of the European System of Central Banks (January, 2023), *Towards climate-related statistical indicators,*
Interviews conducted with Banca Sella

much more complicated is to determine the actual cash flow which is generated by every office or branch. This is a fundamental step for the appropriate assessment of possible impacts driven by extreme weather events, even though it is still characterized by significant blind spots. Such issues will be analyzed more in depth later in this chapter, and the procedure for the division of the territory into segments will be explained and shown in the third and last chapter, where it will be deeply examined a technique for the estimation of flood risk on a mortgage portfolio.

2.1.1.2 Performance and results

Now that the main input variables have been defined and explained, going forward with this paper it should be easier to understand what the ECB climate stress test is about and why large blind spots persist around the correct integration of climate-related and environmental risks into the internal management frameworks of the banks' counterparties, and above all of the banks themselves.

The ECB climate stress test have begun by gathering information from the supervised banks on some key input variables and their stress test projections, which were based on the implementation of common scenarios.

Data have been collected by the ECB though 3 different modules:

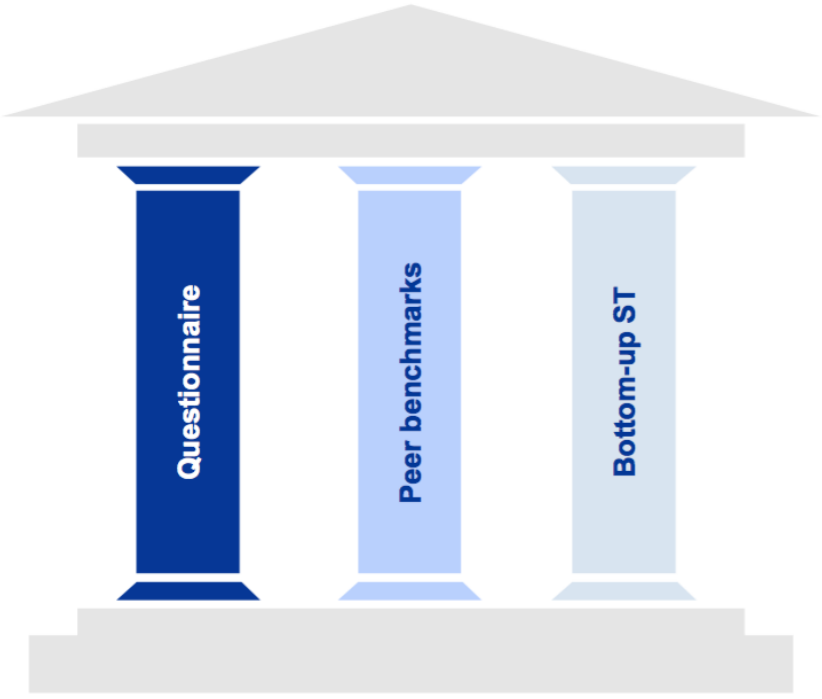

Figure 11[36]: The three modules of the 2022 climate stress test

1) The first module consisted of a qualitative self-assessment questionnaire which aimed to

[36] Source: ECB, *2022 climate stress test*

explore the banks' climate risk stress testing capabilities. The questionnaire was composed of general questions to assess if the banks had put in practice some climate risk stress testing frameworks, and to evaluate the level of integration of climate-related and environmental risks into the banks' business strategy, corporate governance, risk management frameworks and scenario designs.

2) The second module required the supervised banks to provide two climate risk metrics related to the banks' exposure to carbon-intensive sectors, and therefore their sensitivity to transition risks. In order to do so, banks were required to split their current[37] financing exposure among 22 sectors, which were accountable for around 90% of the total Scope 1 emissions at European level. On top of that, banks were also asked to provide data regarding Scope 1, 2, 3 and revenues of their 15 largest corporate exposures for each of the 22 carbon-intensive sectors identified.
3) The third module consisted of the bottom-up stress test, which required banks to provide the most specific and technical data. More precisely, banks were required to provide the outcomes of different scenarios. Such scenarios regarded both the physical and transition risk.

   For what concerns the transition risk, the 2022 climate risk stress test covered two different time horizons. The first one was applied on a long-term horizon of 30 years (until 2050), where the applied scenarios were the ones recommended by the NGFS (with intermediate targets set for 2030 and 2040), namely the *orderly transition* scenario, the *disorderly transition* scenario, and the *Hot house world* scenario. The second time horizon regarded the implementation of a baseline and a stress scenario on a short-term horizon of 3 years. On the long-term scenarios, banks were required to provide their credit risk projections.

   On physical risk assessment instead, there were applied two 1-year short-term scenario on both the risk of incurring *drought and heat* damages, and *flood* damages.

   This complex system of scenarios can be better understood by checking the Figure below.

[37] As of 31st December 2021

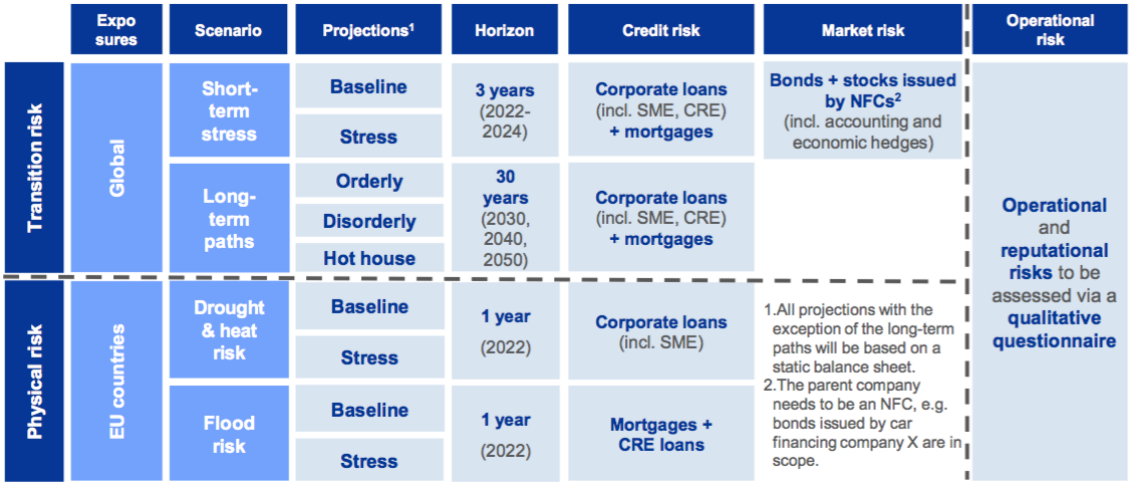

Figure 11[38]: Module 3 scenarios and risk dimensions

With respect to the context of the long-term paths for the assessment of transition risk, it is worth noting that the key distinctive feature that changes over the three different scenarios is the *carbon price*. While in the *orderly scenario* carbon price increases gradually reflecting the gradual implementation of transitional policies, in the disorderly scenario it is witnessed a steeper increase in its value starting from 2040. With regard to the *Hot house world* scenario, carbon price remains flat reflecting the absence of policies to support the transition towards a lower-carbon economy.

To sum up the methodologies explained above, the first module was a qualitative assessment aimed at gaining an understanding on the supervised banks' generic main practices and climate stress test integration into their corporate governance, business strategy and risk management frameworks. The second and the third modules were quantitative evaluations that helped the ECB in developing a precise overview of the exposure of banks towards climate-related and environmental risks through data directly provided by banks and their outcomes of reference scenario analyses.

Results of the first module show that banks have made significant progresses in the management and integration processes of such risks with respect to the previous year, however the path to a complete and satisfactory development of practices among all institutions is still long and uncertain.

In fact, it has been shown by the ECB climate stress test that banks that correctly implement a climate stress-testing framework are 41.35%[39] of the total of the banks supervised, showing an improvement with respect to the previous year where only 25% correctly did it. Even though this improvement comes with some optimism for the future, the fact that more than half of the supervised banks do not currently have a proper climate risk stress-testing framework in place cannot be considered as a satisfactory result. The main reason of these failures is the fact that banks are struggling to gather

[38] Source: ECB, *2022 climate stress test*
[39] ECB, *2022 climate stress test*

climate-related data, as most of their financed counterparties do not currently provide granular data in this regard. As this problem represents one on the main hindrances in this context, it will by addressed more specifically later in this chapter over a dedicated paragraph.

Another relevant issue is that, among the banks which have successfully developed a climate risk stress-testing framework, 60% of them currently do not disclose or intend to disclose any information on the outcomes as recommended by the Pillar 3 developed by the Basel Committee on Banking Supervision.

Furthermore, among the same cluster of banks with a climate stress test framework in place, only the 60% consider its results for the development of their business strategy and only the 19% use it to inform their credit granting areas.

Overall, the outcomes of the first qualitative module can be summarized and be better explained by the graph reported below.

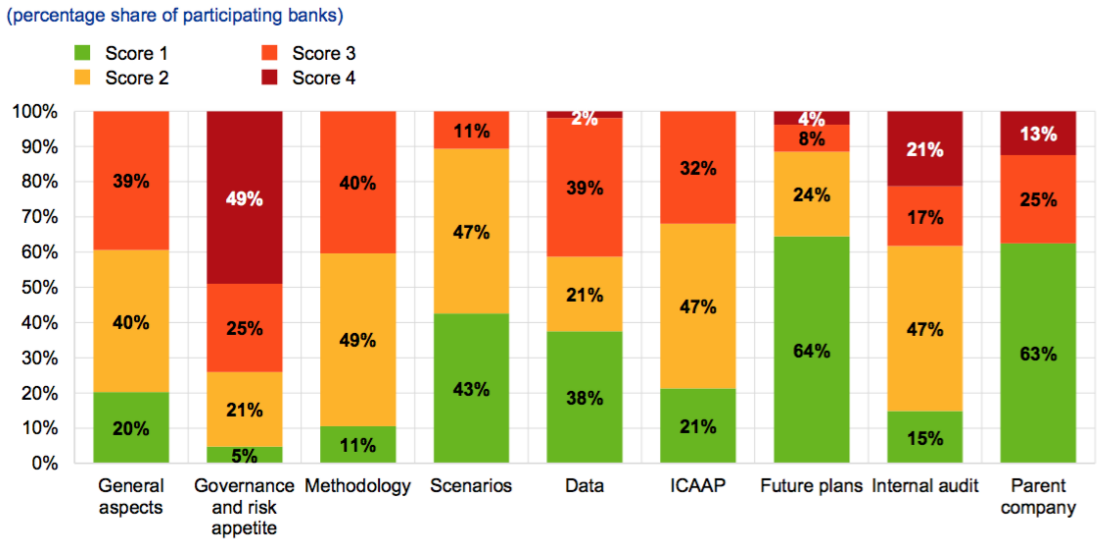

Figure 12[40]: Preparedness across key components of climate-risk stress-testing framework

In the graph, green bars (Score 1) are represented by the use of satisfactory practices by banks, while dark red bars (Score 4) mean that banks do not have a plan for integrating such practices or their approach is widely poor. By analyzing the graph it can be seen that the only area where more than the average of banks implement adequate approaches is on the willingness or plans to develop future frameworks for the assessment and integration of climate-related matters. On the contrary, unacceptable results have been found over several areas, among which the most evident are a scarce integration of climate risks consideration into the areas of governance and internal audit frameworks.

[40] Source: ECB, *2022 climate stress test*

It also have been assessed that the current methodologies in place are widely insufficient, except for the 11% of supervised banks.

2.1.1.3 Collateral findings on banks' exposures

For what concerns the results provided by the second and third quantitative modules, it has been shown that banks are on average exposed on more than half of their financing portfolios towards carbon-intensive industries, thus they will likely have to face transition risk issues over the medium/long term. In fact, more than 60% of interest income of banks comes from counterparties operating in the 22 carbon-intensive sectors identified in module 2.

In this regard, it is important to note that the aggregated gross value added of the 22 sectors accounts for the 54%[41] of the total gross value added in the European economy. Thus, the cash flows that banks are generating from these carbon-intensive sectors goes beyond the relative weight that these sectors have at European level. As a result, there should be margin for banks to shift their sources of income towards more sustainable investments and financings.

However, as a mitigation factor, it should be observed that even though the aggregated exposure to highly polluting sector is overall significant, the largest exposures are towards sectors which lower intensity of emissions, such as retail, wholesale, real estate and constructions, as shown by the graph reported below.

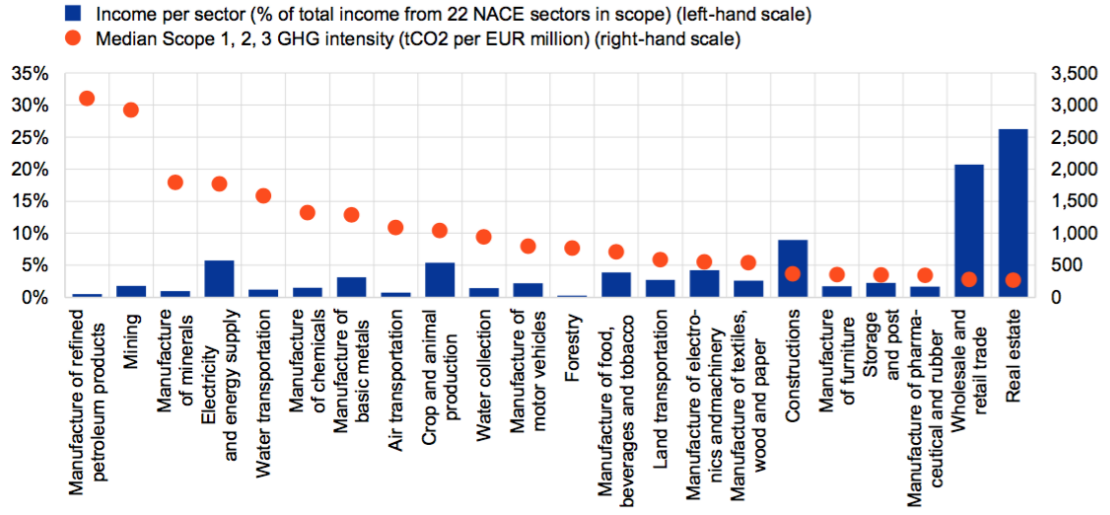

Figure 13[42]: Interest income per sector from the 22 carbon-intensive industries and median of scope 1, 2, 3 GHG intensity

[41] Source: Eurostat

[42] Source: ECB, *2022 climate stress test*

Sectors in the graph are ordered from the one with the greatest environmental impact (manufacture of related petroleum products, to the left) to the one with the least environmental impact (real estate, to the right). Among those which provide a lower but still significant amount of interest income, the most impacting are the energy production and supply sector and the crop and animal production sector.

The degree to which the exposure to such sectors can be impacted by climate risks will depend on whether these financial counterparties have put in place or plan to put in place green transitions frameworks, in order to be consistent with the goals set by the Paris Agreement.

Another relevant fact to be presented is that Scope 3 emission are by far the largest driver of emissions. This further proves how relevant it is for financial institutions and their counterparties to find a way to develop a framework for assessing this type of emissions.

With respect to the results provided by the third module, this chapter will focus on the outcomes of the three reference scenarios[43] provided by the NGFS on the assessment of transition risk.

The ground-breaking characteristic of the 2022 climate stress test is that the ECB required banks to provide their long-term[44] strategies with respect to the same 22 carbon-intensive sectors identified and to forecast the projected losses from these industries over the three NGFS reference scenarios in the next three decades.

Overall, as was easily expected, it has been shown that the forecasted losses are lower under the orderly transition scenario.

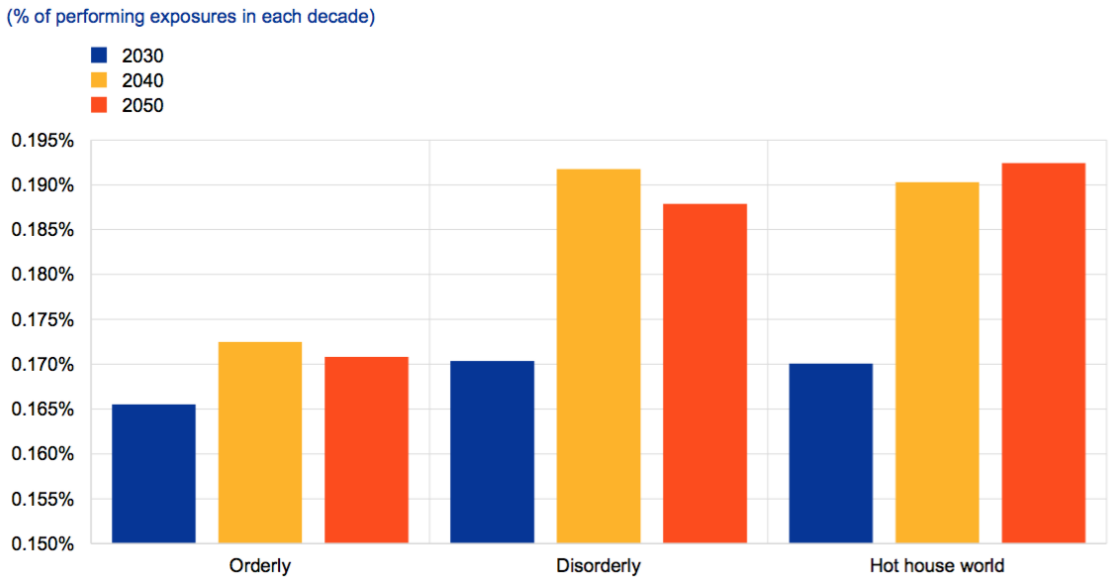

Figure 14[45]: Forecasted loan losses per decade in the long-term transition scenario

[43] The *orderly* scenario, *disorderly* scenario, and *Hot house world* scenario
[44] Over the next three decades
[45] Source: ECB, *2022 climate stress test*

The graph above better shows in quantitative terms the projected losses under each scenario and for each of the following decades.

It is important to note that on average, banks do not project significant difference in losses between the *disorderly* and the *Hot house world* scenarios. One assessment which can be made is that, as of 2040, the disorderly scenario forecasts greater losses since the abrupt transition policies implemented would likely have a great impact on the counterparties' creditworthiness. Such impact is forecasted to carry higher losses than the ones related to the increased physical risk in the *Hot house world* scenario.

However, this trend seems to invert as of 2050, where the projected losses are lower under the *disorderly* scenario. This can be explained as most of the impacts arising from transition risk in the *disorderly* scenario have already been incurred during the previous decade, leading to a slight decrease in the forecasted loan losses. On the *Hot house world* scenario instead, projected losses on loans show an increase because of the adverse effects of extreme weather events, which more than offset the adverse effects related to transition risks in the *disorderly* scenario. This pattern may suggest that as the years go by, let's say over two or three decades after 2050, the effects of transition risk on the *disorderly* scenario should gradually decrease while the impacts related to physical risk should exponentially increase[46] on the *Hot house world* scenario, where no mitigation policy is implemented, leading therefore to an exponential increase in projected loan losses for banks.

Therefore, it could be assessed that on the long-term[47] the outcomes of the *disorderly* scenario and the *Hot house world scenario* should not be similar, rather the scenario where no mitigation policies are implemented should lead to a gradual degradation of the whole economy, besides the obvious effects to the well-being of people and our planet.

Very briefly, it's better late than never to start fighting climate change.

2.2 Challenges to a successful integration of ESG criteria

As it has been explained on the previous chapter, the majority of banks are still at an initial stage for what concerns the integration of climate-related and environmental risks into their internal management practices, even though the banking supervisory authorities have started shedding light on this topic some years ago. The reasons why banks still do not correctly implement these practices are various. For instance, banks may be more focused on short-term financial goals, paying less attention to longer-term risks such as climate change. Either, banks may not have sufficient resources

[46] As stated by almost all scientists

[47] over the time horizon considered in the NGFS reference scenarios

to invest in the development of new risk management tools and processes. Furthermore, they may also lack the expertise to properly address these kind of issues.
Thus, there are many endogenous reasons for the general lack of proper management frameworks with respect to the integration of climate risks.[48]

However, even for the banks which have at disposal the necessary liquidity or the willingness to integrate climate change considerations over all layers of the organization is not easy and straightforward to develop successful integration practices.
Over the next subparagraphs it will be tried to explain which are the main exogenous impediments that prevent banks in their process of climate-related and environmental risks integration and assessment.

2.2.1 Lack of data

As already introduced by the ECB climate stress test, the main reason for banks not being able to carry out proper internal analysis with respect to their real exposure towards climate risks is the lack of available data and the difficulties that banks themselves encounter in actually gathering it.
Difficulties in data gathering regard the data needed for evaluating the transition risk tied to both financing portfolios towards the corporate sector and real estate mortgages portfolios.

For what concerns data directly linked to the financing portfolios to the corporate sector, the most relevant data regard GHGs emissions produced by companies. With regard to *Scope 1* emissions it can already be challenging for banks to collect proper information since emissions data may not be reported in a standardized format, it may be incomplete or inaccurate, or it may not be easily accessible, especially for what concerns small or medium enterprises (SMEs). That said, *Scope 1* emissions represent the easiest input to be collected as they are only related to the direct counterparties involved in the financing.
Scope 2 emissions, which are the emissions produced by the energy, heat and steam suppliers of the involved counterparty, are a little bit more challenging to be collected. This is because data about the involved companies' service suppliers may not be readily available or may not be reported in a consistent and comparable format. Furthermore, many banks have operations in multiple countries, which makes it more difficult to gather data on emissions from all of their facilities. On top of that, it clearly requires more effort to collect data on more facilities with respect *Scope 1* emissions, which are direct emissions generated by a corporation and its directly controlled entities.

[48] Sources: ECB, *2022 climate stress test*,
ECB (November, 2022), Walking the talk - Banks gearing up to manage risks from climate change and environmental degradation

Scope 3 emissions are the ones characterized by the higher degree of complexity in the collection process, since obviously gathering data from the whole upstream and downstream value chain of a certain company is not an easy task.

For these reasons, banks cannot always account on actual and real data to be used as input for their climate stress test. When such real data is not provided by counterparties and cannot be gathered through any other mean, banks must resort to the use of proxies. There are several techniques which lead to the development of proxies. However, even though proxies allow for a proper implementation of any kind of stress test or scenario analysis, as they do not represent the actual value but rather an estimate of it, they cause a wide dispersion of outcome.

Below is reported a graph which shows the percentage in the use of actual data on emissions versus the use of emission proxies in the implementation of the 2022 climate stress test.

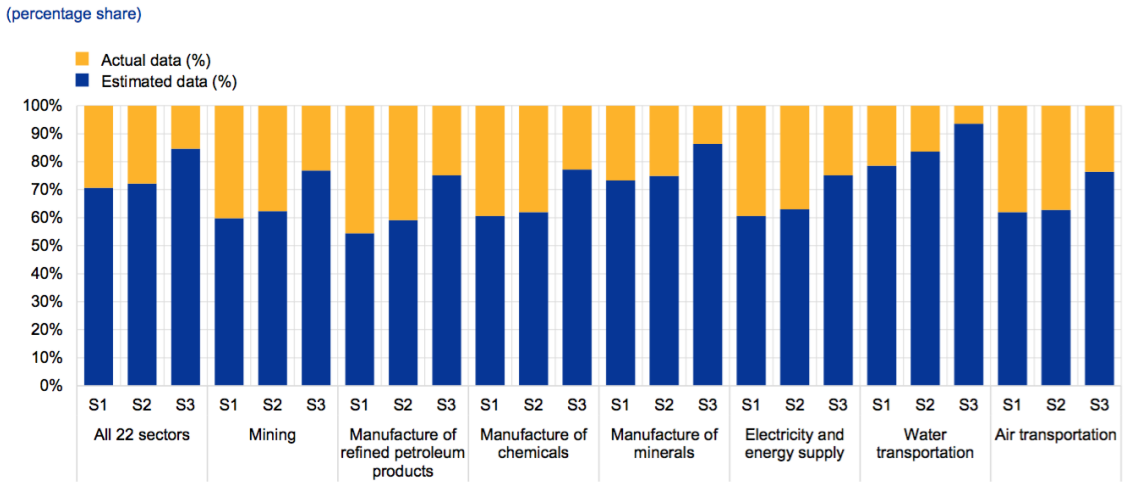

Figure 15[49]: Relative use of actual counterparty data vs proxies for reporting of Scope 1, 2 and 3 emission data

As shown by Figure 15, on average actual data on emission is gathered in around the 30% of cases for *Scope 1 and 2* emissions, while for *Scope 3* emissions actual data is used on around 15% of cases. Such levels represent incredibly low values, so that supervisory bodies are currently working on the definition of a new regulation regarding the mandatory disclosure of emissions at company level.[50]

Banks are facing the same struggles to gather data which could help them in assessing their mortgage portfolios exposure towards climate-related and environmental risks.

The concerned data refers to the Energy Performance Certificates (EPC) of mortgage-backed houses. Collecting data on EPCs can be challenging for several reasons. One of them is that the EPCs are not always mandatory in all countries and in all cases, therefore some of the houses in the portfolio may

[49] Source: ECB, *2022 climate stress test*

[50] ECB (November, 2022), Walking the talk - Banks gearing up to manage risks from climate change and environmental degradation

not have one. Furthermore, the EPCs are usually issued by private energy assessors and the data may not be centralized in one location, making it difficult for banks to collect them all. Another reason is that EPCs are valid for a certain period of time, usually 10 years[51], therefore in some cases banks will have to rely on old data or invest in new assessments. Furthermore, the EPCs are based on a standard methodology, but the quality and accuracy of the assessments may vary, so the banks may not be able to rely on the data provided.

With regard to the 2022 climate strass test, the ECB has assigned to the mortgage portfolios of its supervised banks the EPC ratings displayed in the figure below.

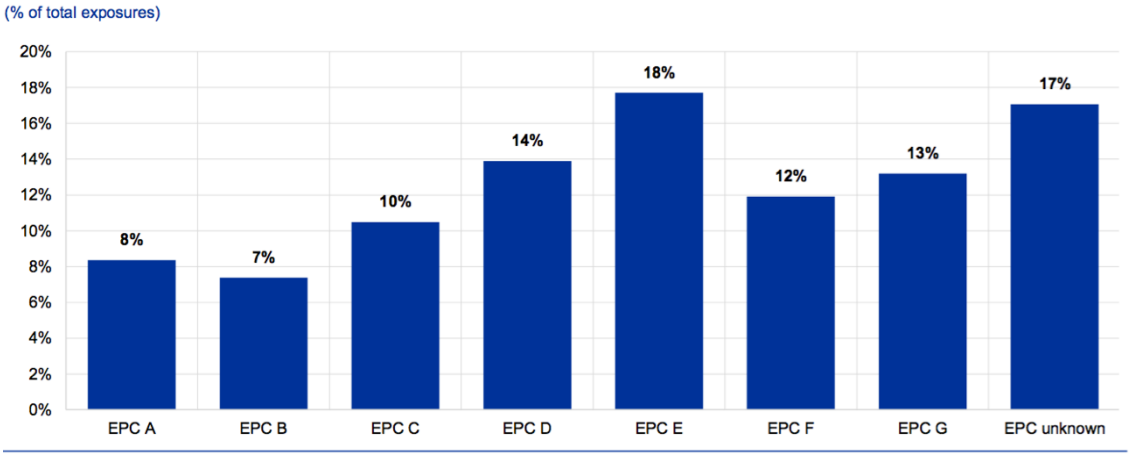

Figure 16[52]: Mortgage and real estate-secured exposures per EPC rating

Among these values, it was reported that the 65% of the banks had to use proxies to determine the EPC ratings related to its mortgage-backed securities. Such a widespread use of proxies could also be considered inappropriate, as proxies often only account on the year of construction and the energy cost of the building, which in some cases are not sufficient to provide an exact outcome for the EPC assessment.

In conclusion, proxies can be considered a useful tool for the performance of climate stress tests and scenario analyses, however, being merely estimates, they often cannot match the exact values involved. Therefore, the banking sector but also general supervisory authorities need to invest in order to help banks to enhance their customer engagement and to develop more advanced data-gathering frameworks, in order for them to become less dependent from the use of proxies.

However, as just stated, it is not just a matter which is dependent on the banking industry.

[51] Certimac, Energy Performance Certificate

[52] Source: ECB, *2022 climate stress test*

The next subparagraphs will outline why also other economic and financial players have a relevant role in the process of disclosure of such sensitive data, and how they could provide their contribution in this context.

2.2.2 The SMEs issue

With respect to the lack of data explained on the previous subparagraphs, small/medium enterprises (SMEs) represent a major issue.

This is because often SMEs lack the resources, data management systems and processes required to gather and disclose comprehensive and accurate data on their climate-related risks and impacts. Besides that, SMEs are currently lacking any incentive to invest in the development of frameworks for correctly assessing GHGs emissions they produce.

This lack of information disclosure is highly relevant for two main reasons.

First, the SMEs account for the majority of the economic gross value added and employees. As an example, at Italian level SMEs account for about 66% of the gross value added[53], while as for Europe the latest SME Report published by the EU Commission showed that they accounted for 53.0%[54] of total European gross value added. In terms of number of entities, the same report states that SMEs represent the 65.0% of total enterprises in Europe. This is a significant data since, as explained above, it is and it will be more challenging to assess the amount of GHGs produced by more than half of the enterprises operating in our continent. In this regard, the only estimation which can be done concerns the relative amount of GHGs produced, whose value has been estimated at around 60%[55] of the total GHGs emitted at European level.

Second, representing more than half of the total enterprises in Europe, they are obviously dispersed along value chains of likely all sectors in the economy. Thus, on top of creating issues for the assessment of their own GHGs emissions, SMEs largely contribute to *Scope 3* emission related to banks' counterparties. As already said, *Scope 3* emissions account for the greatest fraction of the total GHGs emitted, therefore it is straightforward that disclosure issues related to SMEs create a significant impediment to the whole system of climate-related and environmental risk assessment, especially for what concerns the evaluation of transition risk.

[53] Angelini P. (November, 2022*), I rischi finanziari posti dai cambiamenti climatici: carenze informative e piani di transizione,* Banca d'Italia
[54] EU Commission (July, 2021), *Annual Report on European SMEs*
[55] EU Commission (April, 2022), *Annual Report on European SMEs 2021/2022 - SMEs and environmental sustainability Background document*

That said, there is a significant portion of SMEs which have started implementing a transition towards more sustainable practices[56] and have started investing in the development of frameworks for concretely controlling and counting their emissions.

However, it is important to note that some key features of SMEs, such as limited resources and finances due to delayed payments by clients, operations in economic niches and markets characterized by a certain degree of uncertainty limit those enterprises in carrying out investments that could help them in the development of disclosure frameworks and adequate transition practices.

Thus, there is a clear need for regulations provided by supervisory authorities both at national and European level that could help SMEs accelerate their transition processes. Some regulation policies are already under discussion, and further details will be provided in the following paragraphs.

2.2.3 Lack of a shared supervisory framework

Another reason because of which most of banks are unable to properly assess the exposure of their portfolios towards climate-related and environmental risks is the current lack of regulation on these topics by supervisory authorities.

Regulation that is needed for concretely addressing this complicated topic should be addressed mainly towards two areas:

1) ***Corporate and Real estate sectors:*** European supervisory authorities should issue some new regulations in order to support banks' counterparties over the development of their main sustainable practices. In order to do so, new regulations should address the transition towards greener practices for companies by providing mandatory guidelines to be followed in order to be concretely compliant with the targets set by the Paris Agreement. On top of that, probably it is more urgent to provide mandatory regulations to both the corporate sector and the real estate sector for the correct disclosure of climate-related data. That is, some regulations that should direct companies, and especially SMEs, to the development and implementation of frameworks to correctly assess their GHGs emissions, and for the real estate sector to correctly identify in an easier way the EPC ratings of mortgage-backed buildings and houses.

   It has already been extensively stressed how fundamental it is to have actual data to analyze in order to properly assess the real exposure to climate-related risks of companies, real estates and in turn banks.

   Supervisory authorities are already currently working on the development of mandatory regulations for the correct disclosure of climate-related data, even though the path towards the

[56] EU Commission (April, 2022), *Annual Report on European SMEs 2021/2022 - SMEs and environmental sustainability Background document*

implementation of such practices will take some more years. These regulations will be analyzed more in depth over the next paragraph.

2) ***Banking sector:*** The banking sector should also be supported in the process of data gathering for the correct implementation of climate stress tests.
Several guidelines have already been provided to banks on how to carry out proper analyses, as explained back in Chapter 1. However, banks are facing significant struggles in obtaining useful information by interfacing with their counterparties, which is why also banks should be provided with some common methodologies and frameworks in order to make the analyses of such counterparties more effective.[57] This is important because, besides obviously helping banks in managing their climate-related frameworks, it would ensure an *harmonization* of data across all banks at European level.

2.3 Areas of improvement and possible remedies

The previous paragraphs aimed at providing an overview of the current state of the banking sector in the process of addressing climate-related risks and integrating them into their internal management frameworks. As it has been explained, many banks have already started integrating those practices into their internal organizations, while others currently lack the internal capabilities to properly address this kind of issues. On top of that, both the banks which have put in place developed frameworks and those which have not, must face serious challenges while gathering real data which is necessary for the correct performance of individual stress testing frameworks.

With respect to the features just recalled, this paragraph has the main goal of outlining which are the principal remedies (in the form of regulations) that supervisory authorities are working on in order to support the financial system, and what are the main areas where banks should invest money and effort in order to enhance their control capabilities of climate-related and environmental risks.
Therefore, this paragraph will be divided in two main parts: first, it will analyze the areas where supervisory institutions are considering to intervene to foster continuous progresses and enhance disclosure of data by banks' counterparties. Then it will focus on what banks can do and how they should act to enhance their internal operating and control frameworks for a better assessment of their exposure towards climate risks.

[57] Source: interviews conducted with Banca Sella

2.3.1 Further policies and regulations

The policies and regulations which will be outlined throughout this paragraph are aimed at addressing several areas of such a vast topic as the financial threats posed by climate change. Some of them will regard general policies that are merely directed to discourage an extensive use of polluting practices, while others are more specific with regard to the information to be disclosed by companies and any other entity to make the whole system more aware of the challenges and more straightforward to be managed and controlled.

2.3.1.1 Transitional policies

The first kind of policies which will be outlined throughout this paragraph regard the transitional policies aimed at fostering carbon neutrality. There are several policies which have the goal of reducing GHGs emissions to a level which can be absorbed by the Earth's natural processes. Among them, there can be found policies aimed at fostering renewable energy by setting targets and providing incentives, policies aimed at improving energy efficiency in buildings and transports, and policies aimed at providing incentives for investing in low-carbon technologies.

However, the arguably main transitional policy which is being developed[58], and the one which has a more significant relevance in the analysis of this paper[59], is the one related to the implementation of a carbon tax on emissions. Carbon tax can also be referred to as carbon pricing which, as already explained at the beginning of Chapter 2, refers to the pricing of carbon or GHGs emitted by companies.

There can be applied various kinds of carbon taxes, both at economy-wide level or at sectoral level, each with its unique design and objectives.

However, the two main types of carbon pricing methods which is worth analyzing more in depth are the *carbon tax* and *the emission trading scheme (ETS).*[60]

- The **carbon tax** is a pricing mechanism which consists of a tax level on the emissions of carbon dioxide (CO_2) and other GHGs. It basically creates a disincentive to emit carbon by placing a price on emission. The greater the tax, the greater the disincentive to produce carbon emissions. Thus, it is the most straightforward pricing method. Its main peculiarity with respect to the ETS pricing method, is that is provides for certainty on the future price of carbon emissions.

[58] Banque de France (February, 2021), *The role of central banks in the greening of the economy*
[59] Carbon pricing is one of the main input variables of the scenario analyses and stress test frameworks performed by banks
[60] IMF (July, 2022), *More Countries Are Pricing Carbon, but Emissions Are Still Too Cheap*

- The **Emission Trading Scheme (ETS)** method, also known as the **cap-and-trade** system, sets a limit on the total amount of GHGs which can be emitted by a certain entity. Under this method, companies receive or buy emissions allowances which they can trade with each other if needed. As opposed to the carbon tax method, the ETS method provides certainty over future emissions levels, even though the aggregated result should be similar to the one provided by the previous method. The main downside of this method is that it comes with complexities it its design, implementation and administration.

The graph below shows the distribution of these methods among countries in the world.

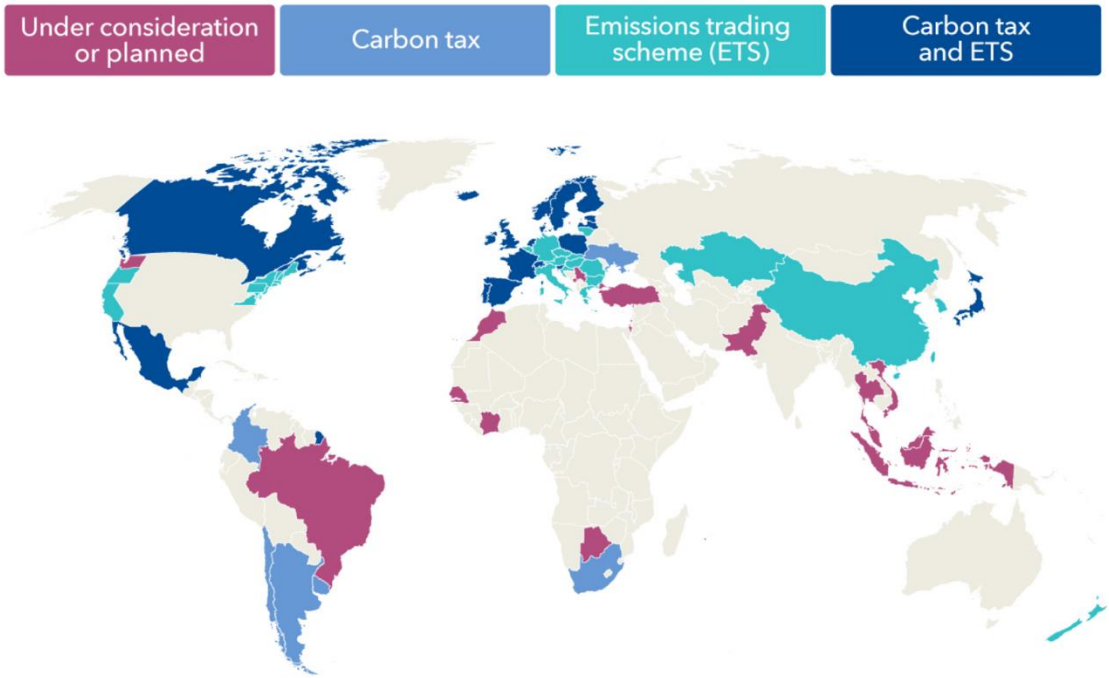

Figure 17[61]: Carbon pricing choices

Figure 17 clearly shows that many countries still have to put in place a carbon pricing framework thus, as a matter of fact, the process of reaching carbon neutrality is being slowed down. Particularly, it is worth noting that the USA[62], India and Russia, which are respectively the second, third and fourth greatest GHGs emitters[63], do not even plan to consider introducing a carbon pricing system.

With respect to the introduction of regulations to enhance the resilience of the financial systems, several authoritative sources such as Banque de France and the IMF state that carbon pricing mechanisms are a necessary feature for providing incentives to companies to be consistent with the targets set by the Paris Agreement, and to play a leading role in the transition towards carbon

[61] Source: IMF (July, 2022), *More Countries Are Pricing Carbon, but Emissions Are Still Too Cheap*
[62] In the USA some states, such as California, Oregon, Washington, Pennsylvania and Massachussets have introduced carbon pricing schemes, as it can be seen by Figure 17
[63] Il Sole 24 ore, *COP27 – le emissioni di CO_2 paese per paese*

neutrality. That said, they are still considered to be too low and should be increased further in order to provide a real environmental benefit.

With specific respect to the analysis carried out by this paper, carbon pricing regulations are relevant since they allow, besides clearly supporting the transition towards a greener economy, to provide banks actual and real data regarding a necessary input variable for the performance of scenario analyses and stress testing frameworks.

2.3.1.2 Landscape of regulations for disclosure enhancement

The regulatory framework that will be analyzed over this paragraph refers to the enhancement of disclosure frameworks, which are vital to ensure a better assessment of the exposure of banks, companies and buildings to climate-related and environmental risks.

The following regulations are to be considered complementary to the ones explained over Chapter 1, however, since the development of the regulatory framework about climate related disclosure is still in progress, it will be seen as an incomplete practice which in the near future will bring notable enhancements to the current disclosure framework.

Upcoming regulations which will be likely put in place over the next years are about to be explained below.

The EU Commission has proposed in April 2021 a regulation regarding a Corporate Sustainability Reporting Directive (CSRD), which is intended to come into force by the beginning of 2024. Since then, financial and non-financial companies that will fall under the scope of the directive (large enterprises and, starting from 2026, listed SMEs) will have to provide a Non-Financial Disclosure (NFD) according to sustainability standards which are being developed by the European Financial Reporting Advisory Group (EFRAG).[64]

Under the CSRD companies will have a mandatory duty to provide more detailed information with respect to the actual legislation in place, which is the Non-Financial Reporting Directive (NFRD). Furthermore, the CSRD greatly expands the range of companies subject to the regulation, as from 2026 also listed SMEs will be mandated to disclose the relative climate information. Non-listed SMEs will also be allowed to provide their climate-related disclosure under the CSRD framework on a voluntary basis. However, the absence of specific incentives for SMEs to provide disclosure on climate matters still represents a major issue for the data collection process.

The introduction of such a regulation will be positively affecting banks' climate-related practices in two ways. First because they will have at disposal better information coming from a greater pool of

[64] Angelini P. (November, 2022*), I rischi finanziari posti dai cambiamenti climatici: carenze informative e piani di transizione,* Banca d'Italia

companies (among which some SMEs), second as they will also be subject to the regulation. Therefore, they will also have to provide more information on their climate-related practices, fostering a significant increase in general awareness among the whole economic and financial system. Below it will be provided a timeline regarding the likely effective implementation of the aforementioned policies.

Figure 18[65]: Expected timeline of CSRD implementation

Furthermore, in this respect, starting from 2024 banks will have to assess some key indicators on their counterparties' activities with respect to their alignment with the EU Taxonomy. Such indicators are the *Green Asset Ratio (GAR)* and the *Banking Book Taxonomy Alignment Ratio (BTAR).*[66]

Another regulation which is on its way to be implemented is the Corporate Sustainability Due Diligence Directive (CSDD). This directive would introduce an obligation for large financial and non-financial enterprises to identify, prevent, mitigate and account for the negative externalities they generate regarding human rights and environmental impacts. On top of that, intermediaries would have to either refrain from investing in counterparties with adverse impacts on human rights and the environment, or establish potentially very costly impact mitigation and reduction measures in this regard.[67] This regulation is intended to have a positive effect over all the value chain of large enterprises: Finally, the CSDD should also introduce an obligation for large enterprises to develop concrete transition plans in order to be consistent with the targets set by the Paris Agreement.

[65] Source: CDSB – *What we do – Expected timeline*
[66] Source: Interviews conducted with Banca Sella
[67] Angelini P. (November, 2022*), I rischi finanziari posti dai cambiamenti climatici: carenze informative e piani di transizione*, Banca d'Italia

The aforementioned regulations represent a huge step for the financial system as a whole to foster a widespread increase in awareness, thanks to enhanced disclosure practice.

2.3.1.3 Frameworks to gather standardized data

Having addressed the majority of the challenges that currently prevent banks to correctly perform an assessment of climate-related and environmental risks, EU financial supervisors still need to make sure that data available to banks is properly harmonized in order to facilitate the processes of evaluation of banks' counterparties' exposure to climate risks.

With respect to banking disclosure, the current framework (namely the art. 449 bis CRR II) relative to the Pillar 3 on banking supervision issued by the BCBS, requires large listed financial intermediaries to disclose information on their assessment of ESG risks. This disclosure is expected to be annual as of 2022, while starting from 2023 it will be expected to be semiannual.

In this regard, EBA has published in January 2022 the *"Final draft implementing technical standards on prudential disclosures on ESG risks in accordance with Article 449a CRR",* which requires banks to compile:

- 3 qualitative tables, with regard to ESG risks incurred by the bank or financial intermediary concerned.
- 10 quantitative tables, which are mostly related to the exposure of concerned banks or financial intermediaries towards sectors which are more likely to be impacted by events related to the materializing of physical and transition risks.

The information disclosed in this tables is expected to evolve over the next few years. More specifically, until the end of 2023 banks will have to provide qualitative information on their ESG characteristics, plus quantitative information regarding their KPIs, physical risk, transition risk, GAR and other mitigation measures. Since June 2024 instead, banks will have to disclose quantitative information on all the areas listed above, ESG features included. Such data should include their direct GHGs emissions, and the GAR computation on their whole portfolios.[68]

By correctly completing these tables required by EBA, banks will be able to disclose their climate related information in a consistent way across all financial intermediaries, ensuring an enhanced quality of information disclosed and an enhanced comparability of data among different financial institutions by EU financial supervisory authorities.

[68] Source: Interviews conducted with Banca Sella

Still needs to be addressed one last problem, which is relative to the challenges banks are facing in gathering data on their counterparties' emissions and on the average EPCs of their mortgages portfolios.

For sure the implementation of the CSRD will be an extremely useful tool for gaining access to a greater amount of data on banks' counterparties, still there will be some companies (such as the non-listed SMEs) which will not be obliged to disclose any information, and which therefore will create a significant gap on the completeness of data available. Furthermore, regarding EPCs assessment, no progress has been made and often national and regional registers present uneven and certainly inaccurate data. Therefore, at least on this regard, there is an urgent need for the development and enhancement of national and regional data registers in order from them to provide more accurate data on EPC ratings.

With respect to both EPCs and Scope 1, 2, and 3 emissions, one possible remedy could be the creation of a unique and uniform ESG platform by regulatory bodies and supervisory authorities where all financial intermediaries can find all available data related to all the different norms such as the EU Taxonomy, NFD, Pillar 3 and CSDR. Available data on emissions should be provided by the concerned players, so that financial intermediaries but also any interested entity would take advantage from a transparent framework for the data collection process.

For unavailable data instead, the platform should provide guidelines on the proper use of proxies based on shared metrics, in order to ensure an accurate comparability of information, also with regard to estimated data.[69] However, in this regard, it is relevant to recall that the use of proxies comes with great limitations as they only represent an approximation of the actual values sought. Thus, they are to be considered as an intermediate step before being able to get the exact data.[70]

As a concluding remark, regulatory bodies should progressively introduce mandatory norms for the disclosure of information among all banks' counterparties, including all SMEs and buildings constructors with regard to the EPCs.

2.3.2 Critical areas of banks' internal frameworks

The previous paragraph focused on the actions taken by supervisory authorities to provide some concrete improvements to the context where banks and financial institutions operate, with respect to climate-related and environmental risks.

[69] Source: interviews conducted with Banca Sella

[70] EBA (2021), EBA Report on management and supervision of ESG risks for credit institutions and investment firms

Thus, after having analyzed the efforts of administrative bodies, this paragraph will focus on what banks can do better to foster a constant enhancement of their integration practices of climate related matters into their operations.

As outlined by the ECB Guide in 2020, banks should focus over four main areas, namely: *strategy, governance, risk management* and *disclosure*. As disclosure practices have been extensively addressed over the previous paragraph, and risk management frameworks will be described more in detail in the last chapter of this paper, this paragraph will try to address mainly the internal areas of banks' strategy and governance. In order to do so, it will be analyzed the current observed practices in place, some possible remedies and the best observed practices among the supervised entities.

2.3.2.1 Strategy and KPIs

With respect to banks' business strategy implementation relative to climate-related and environmental risks, the ECB Guide has outlined in 2020 two main expectations. Such expectations require banks first to understand the threats posed by climate-related and environmental risks over the short, medium and long term on the sectors towards which banks are exposed. Second, banks are expected to concretely integrate climate risks considerations when determining and implementing their business strategy.

As of 2022, evidence shows that banks have taken the first steps to understand what are the possible impacts on climate-related events on their counterparties, but overall banks' business strategy still cannot be considered resilient to these risks.[71]

With respect to the integration of such risks into banks' internal management frameworks, the majority of institutions have started determining the actual impact of climate risks into their business strategy, and most importantly have started developing Key Performance Indicators (KPIs) to provide a strategic response to such issues. KPIs include the amount of exposure towards counterparties' operating in highly carbon-intensive sectors and the communication of their goal to achieve net-zero emissions by 2050.

However, the development of such KPIs is still at an initial stage as banks overall have not adopted yet enough forward-looking practices that explain what will be their strategic response to the materialize of climate-related risks.

[71] ECB (November, 2022), Walking the talk - Banks gearing up to manage risks from climate change and environmental degradation

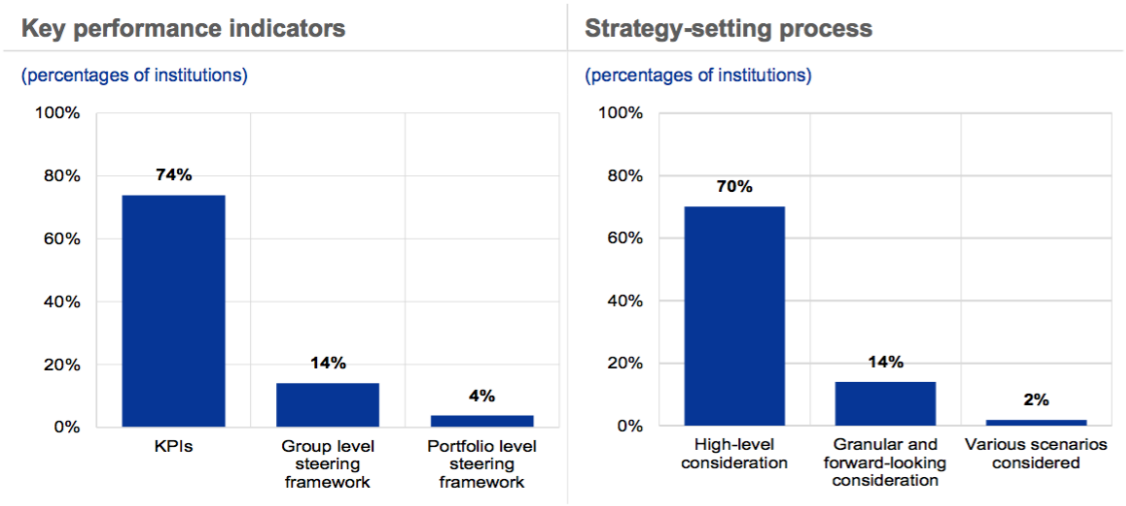

Figure 19[72]: Climate-related risk practices in business strategy

The graphs above provide the results of a study conducted by the ECB on a sample of 107 financial institutions. With respect to the graph on the left, it can be seen that most of the institutions have already adopted the integration of KPIs into their business strategy, however only 14% of the studied sample have provided details on the effective ways through which the intend to reach the aforementioned KPIs. On top of that, only 4% of banks have developed concrete KPIs-oriented strategies to be applied on their financing portfolios.

For what concerns instead the effective implementation of strategies in response to climate change consideration, the 70% of banks in the sample has developed basilar strategies frameworks, while only the 14% of them has started employing forward-looking tools to assess the impact on climate risks and to use the outcomes provided by such tools to develop a proper business strategy. Last, only a smaller set corresponding to the 2% of the sample analyzed uses various scenario analyses to assess the goodness of strategies identified.

Overall, among the two graphs only the 8% of banks considered still have to identify KPIs on their strategies, and only the 14% still has to define strategies to be implemented as a response to climate-related and environmental risks.

Thus, it seems that the vast majority of banks have started to direct their business strategies also towards climate related matters, but they still need to make significant progresses in order to provide overall satisfying results. In fact, evidence shows that most institutions are taking a wait-and-see approach before making significant investments on the enhancement or development of frameworks for the assessment of climate change impact and its related integration into their strategy.

[72] Source: ECB (November, 2022), *Walking the talk - Banks gearing up to manage risks from climate change and environmental degradation*

Among the best practices observed, the correct performance of several transition scenarios seems to be the most useful tool that allows to gain a proper understanding of the risks posed by climate change and to provide the basis for the development of responsive business strategies.[73]

2.3.2.2 Governance and KRIs

For what concerns instead the development of appropriate governance frameworks, overall it seems that banks have brought to the highest levels of governance climate-related consideration. However, also for what concerns this are of analysis banks are at the initial stage of addressing climate-related consideration in a scrupulous way.

In this respect, the ECB's expectations outlined in the ECB Guide required banks to consider climate-related risks when designing their business strategy and risk appetite frameworks. Furthermore, financial institutions are expected to internally report aggregated risk data that reflect their exposure to climate risks, and to assign to different management bodies within the organization responsibilities for the evaluation of climate-related matters.

Briefly, a clear organizational structure with defined roles and lines of responsibility is critical for an appropriate management of climate-related and environmental risks.

With respect to the last expectation outlined, evidence shows that the majority of banks have successfully assigned roles and responsibilities to management bodies or sub-committees. In some cases, banks have also created ad-hoc committees for the management of climate change within the Board of Directors.

Banks have also generally gained awareness of data gaps for the performance of specific scenario analyses and stress test, and have started taking remedial actions in this respect. However, only a small subset of banks has developed frameworks for collecting granular data, also because, as already stressed, it is not a matter which is only under banks' control.

The graph below will provide additional evidence of what has been examined so far.

[73] ECB (November, 2022), *Good practices for climate-related and environmental risk management - Observations from the 2022 thematic review*

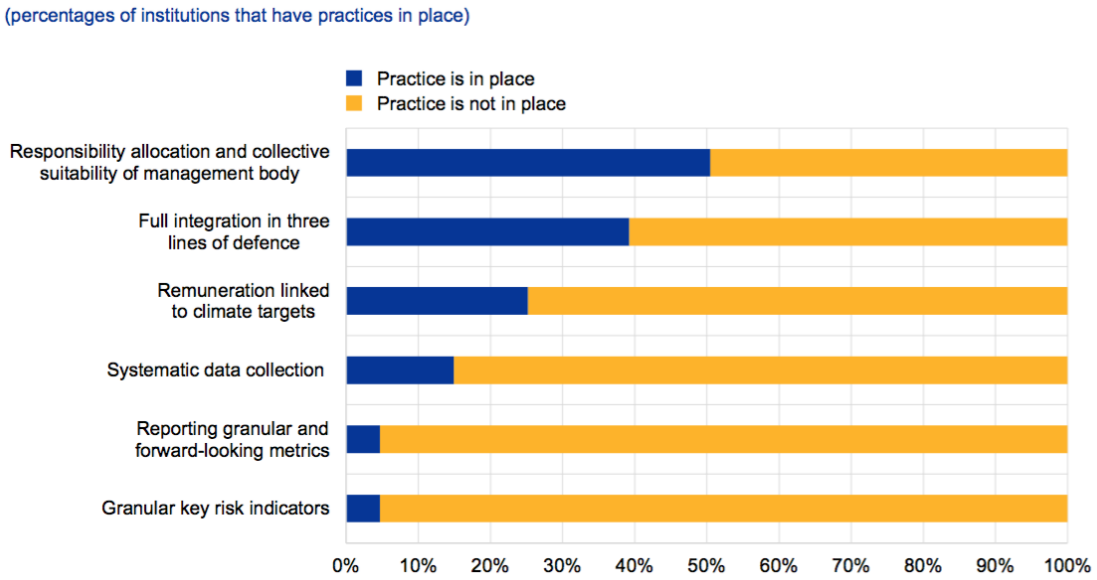

Figure 20[74]: A structured, integrated and granular governance of climate-related risks

The most significant fact which can be inferred from the graph above is that only about 5% of banks analyzed in the sample has developed granular Key Risk Indicators (KRIs). Even though this data represents an improvement with respect to the previous year, where none of the banks examined had put in place KRIs, it testifies that banks still have to develop frameworks which allow a proper integration of risk-sensitive data.

Therefore, additional effort is needed by financial institutions, especially for what concerns the areas of data gathering and KRIs development and integration.

For what concerns the best practices observed in this context, De Nederlandsche Bank (i.e. the Central Bank of Netherlands) has identified a bank which has updated its governance framework in order to properly address the threats related to climate risk. This bank has created a framework to understand the climate risks towards which it is exposed, and has ensured that the management directly oversees this kind of practice. On top of that, the management's remuneration is linked to the achievement of targets related to climate-risks assessment.[75] Thus, this bank ensured that climate change considerations are addressed over all layers of the internal management.

As a conclusion of this paragraph, which is related to the corrective actions that have to be taken to foster transparency and the spread of good practices among financial institutions, it is worth stressing that no remedy alone can provide a significant enhancement to the context of climate risks integration into banks' internal management frameworks.

[74] Source: ECB (November, 2022), *Walking the talk - Banks gearing up to manage risks from climate change and environmental degradation*

[75] De Nederladsche Bank, Good practice - Integration of climate-related risk considerations into banks' risk management

Rather, it is needed a joint effort by supervisory authorities and banks themselves to make sure that data gaps can be overcome, and that the financial system as a whole can take advantage from a widespread integration of climate risks consideration, in order to drive a just transition towards carbon neutrality.

2.4 Future supervisory expectations

As one of the main financial supervisory authorities, the ECB will keep supporting a constant development of regulations and guidelines for banks to improve their internal management frameworks for climate risk assessment. Other than working alongside other supervisory authorities such as the EU Commission for the development of the aforementioned policies, under the ECB responsibilities is also to make sure that financial stability is always preserved. To do so, the ECB aims at making sure that the critical areas previously identified are properly addressed.
The following paragraph will go more in depth on the main ECB's future priorities.

2.4.1 ECB climate agenda

As climate change poses serious threats to financial stability, it is also an ECB's responsibility to ensure that the financial sector develops appropriate measures to tackle climate related risks.
The ECB aims to do so by focusing on three main objectives, which will be displayed in the figure below:

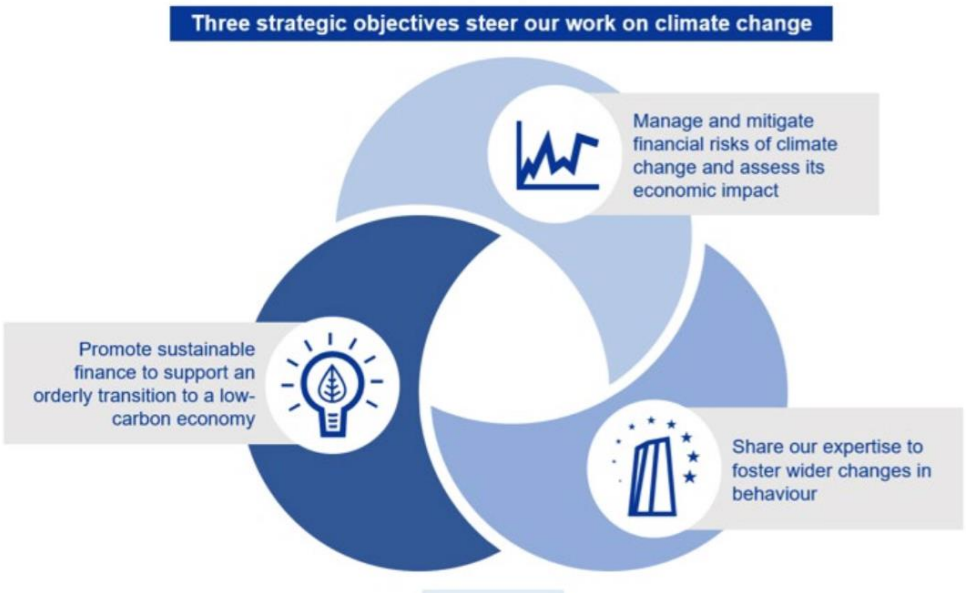

Figure 21[76]: ECB's core strategic objectives

[76] Source: ECB (July, 2022), *ECB climate agenda*

With respect to the general objectives shown in Figure 21, the ECB will focus on six main priority areas, namely:

1) *"Assess the macroeconomic impact of climate change and mitigation policies on inflation and the real economy"*

   Actions that will be carried out in order to comply with this strategic priority include the evaluation of macroeconomic impact related to the implementation of climate mitigation policies, and the inclusion of climate considerations into the macroeconomic models and indicators such as inflation, aggregated output and monetary policies.[77]

2) *"Improve the availability and quality of climate data to better identify and manage climate-related risks and opportunities"*

   To comply with this objective, the ECB will work on the development of experimental data indicators and, by 2024, of statistical data collections to be used for climate-related and environmental risk analyses.

3) *"Enhance climate change-related financial risk assessment"*

   The ECB will develop and carry out another climate stress test, which this time will be even more precise and will be focused on the Eurosystem balance sheet. On top of that, it will support the integration of climate risks into the credit risk areas of banks by reviewing the impact of climate-related and environmental risks in credit ratings.

4) *"Consider options for monetary policy operations and assess the impact of climate change on monetary policy"*

   To do so, the ECB will introduce climate disclosure as an eligibility requirement to be produced as supporting documentation of asset purchases. Again, with respect to asset purchases the ECB will work on the development of proposals to ensure a constant consideration of climate related matters.

5) *"Analyze and contribute to policy discussions to scale up green finance"*

   The ECB will keep working alongside other European policy makers to evaluate the role of green financial instruments on the transition process towards net-zero, by providing analytical supporting documentation to communicate its policy positions.

6) *"Increase transparency and promote best practices to reduce the environmental impact"*[78]

   Last, the ECB will keep working on the development of guidelines and regulations for climate-related financial disclosure in order to foster a continuous enhancement of transparency for the corporate and financial sector. On top of that, it will try to increase the

[77] ECB roadmap 2022 - 2024

[78] ECB (July, 2022), *ECB climate agenda*

environmental sustainability of the cash cycle and keep the public informed about the progresses of the financial sector with respect to the targets set by the Paris Agreement.

The second chapter of this thesis aimed at providing an overview of the current features of the financial sector with regard to the management of climate-related and environmental risks. It sought to be explanatory by outlining the main characteristic, the grey and critical areas, and the possible remedies that supervisory authorities and bank themselves could work on to ensure an enhancement of transparency and a better integration of climate-related practices into the internal frameworks of banks.

Having provided a broad description of the current context, the following and last chapter of this paper will focus more specifically on risk management practices that banks have at their disposal to effectively quantify physical and transition risk.

3. CLIMATE RISK ASSESSMENT FRAMEWORKS

The last chapter of this paper aims to provide a detailed description of some of the current methods that financial institutions employ to assess in quantitative terms the impact of physical and transition risks on their financing portfolios.

The analysis will start with a review of the latest guidelines provided by the ECB, particularly through the Statistics Committee of the European System of Central Banks (ESCB), with regard to the correct development of statistical indicators to be used as fundamental inputs for the performance of risk managements practices.

Following that, the focus will be moved on the effective implementation of risk assessment models: first, with the support of a technical paper issued by Intesa Sanpaolo and Prometeia,[79] it will be assessed the effect of physical risk, particularly the flooding risk, on an Italian residential mortgages portfolio. Then, after the physical risk analysis, it will be examined the possible practices that can be put in place to assess the transition risk for banks. As it will be seen, currently there is not a commonly adopted framework for gaining a correct and precise evaluation of transition risk's impact on financial institutions, but the whole system is working on finding a solution to this problem.

3.1 Introduction on the development of climate statistical indicators

As already extensively stressed, in order to ensure a proper management of climate-related and environmental risks financial institutions need to collect high-quality data and indicators. The ECB, as the main supervisory authority with regard to financial stability matters, has entrusted to the Statistics Committee of the European System of Central Banks to develop common frameworks for the creation of climate change statistical indicators. Such a creation process obviously comes with great complexities which are related to the need of matching and harmonizing micro-variables of different cross-country datasets. Furthermore, the development of imputation mechanisms for the assessment is also a complicated task, especially with respect to emissions data and energy efficiency of buildings[80]. Therefore, as it will be seen more precisely later in this paragraph, such data will be published and considered as *analytical indicators* (or, as they have been called previously in the paper, *proxies*), meaning that they do not represent the actual value concerned, but rather they represent work-in-progress data which still can be considered relevant if used judiciously and accompanied by a suitable explanation.

[79] Prometeia is a consulting company which is specialized, among the others, in providing advisory services on risk management practices

[80] ECB, Statistics Committee of the European System of Central Banks (January, 2023), *Towards climate-related statistical indicators*

The main indicators examined by the Statistics Committee of the ESCB can be split among three areas, depending on their different application in the climate change context, and which are released at different levels of maturity:

1) *Sustainable finance indicators* relate to the issuance or holding of leverage instruments which have sustainable feature, or can be considered compliant to the EU Taxonomy. Such indicators provide information about all the stages of the sustainable financing processes, and are useful because they enhance transparency about financial markets and the effective performance of ECB's monetary policy practices. Even though these indicators' dataset is the most developed among the climate-related ones, *sustainable finance indicators* will not be further analyzed as they have the least correlation with the main topic of this chapter, which is the evaluation of physical and transition risk by financial institutions.
2) *Physical risk indicators* relate to the possible impact of climate-related extreme events on banks' loans, bonds and equities. They can be used to assess the effective impacts of physical risk and compare them across different countries and sectors. As previously introduced, this kind of data is to be considered as work-in-progress since it is still not always possible to assess in a precise way the location and vulnerability of certain buildings, both for what concerns warehouses and offices belonging to banks' financed counterparties, and mortgage-backed buildings and houses. The development of such indicators will be analyzed more in depth later in a dedicated paragraph.
3) *Carbon emission indicators* are strictly related to the assessment of transition risk for banks' counterparties, thus obviously also of transition risk for financial institutions themselves. These indicators aim to provide data on GHGs emissions of banks' counterparties, in order to assess the overall exposure of financial institutions' financing portfolios towards carbon-intensive sectors and activities. Thus, thanks to these indicators, it should be possible to assess transition risk in the context of financial stability, monetary policies and banking supervision. As it was for physical risk indicators, also carbon emission indicators are to be considered as *analytical indicators,* and need to be provided along with a suitable explanation.

It is important to recall that the ECB is working alongside other supervisory institutions to ensure a greater availability of data to be used by financial institutions, namely the International Monetary Fund (IMF), the Financial Stability Board (FSB), the Basel Committee on Banking Supervision (BCBS), the G20 and the Network for Greening the Financial System (NGFS).

On top of that, the upcoming regulation which will be effectively implemented over the next few years, such as the aforementioned Corporate Sustainability Reporting Directive (CSRD) will enhance the current framework and provide access to a greater amount of available data.

Following, it will be provided more specific analyses of indicators relative to physical and transition risks, shedding light on the sources of concerned data and the challenges faced by the Statistics Committee of the ESCB in developing appropriate framework.

3.1.1 Analytical indicators on physical risk

Extreme weather events can be the cause of significant damages for the financial system: for instance, a damaged bank's counterparty may not be able to fully service its debt because of the reconstruction costs, or any borrower's damaged collateral would actually lose its value. For this reason, it is important for financial institutions to assess the value associated to extreme weather events and, in order to do so, to gather the relative data for ensuring a proper performance of the analyses involved. This paragraph will mainly focus on the data collection process and the development of risk statistical indicators, while the effective performance of the relative physical risk assessment will be addressed later in a dedicated paragraph.

Analytical indicators on physical risk should be developed in close relation for every natural hazards (e.g. extreme meteorological and hydrological events such as floods, extreme heat events and related consequences such as wildfires, but also storms and hurricanes), however this paragraph will consider the development of common indicators which can be useful for the assessment of any natural hazard. On top of that, the main focus of the analysis will be the indicators of risk related to extreme weather events rather than chronic risks such as the sea-level rise. This is because, even though there is a greater data availability for chronic risks, under a real quantitative perspective acute risks can be linked to physical damage in a more exact way.[81]

Physical risk is to be considered as a result of the interaction of three main components, which can be arranged over three layers[82]:

1) ***Hazards:*** analysis of extreme weather events in terms of frequency of incidents, severity and probability of occurrence in a specific location and under a specific scenario.
2) ***Exposure:*** provides information on how banks are exposed to such risks, by analyzing how eventual damages to financial institutions' counterparties may in turn affect financial institutions themselves. It involves an examination of banks' investments such as equities and bonds and the related collateral securities, in terms of their location, if they have an insurance in place[83], etc.

[81] ECB, Statistics Committee of the European System of Central Banks (January, 2023), *Towards climate-related statistical indicators*
[82] ECB, Statistics Committee of the European System of Central Banks (January, 2023), *Towards climate-related statistical indicators*
[83] Source: Interviews conducted with Banca Sella

3) ***Vulnerability:*** an assessment of the vulnerability of physical assets involved is necessary in order to be able to translate hazard data into monetary expected losses. Generally, to perform this kind of practice banks take advantage of damage functions. More detailed information on the damage function and on the translation of risks into expected losses will be provided later in the *physical risk assessment* paragraph.

A fourth element, which works as a link for the three previously analyzed components is the ***geolocation***, since every component is to be specifically analyzed based on the geolocation of assets. Thus, availability of specific and granular geolocational data is a fundamental prerequisite to combine the three elements which have just been explained.

With respect to the extreme weather events and the background provided, three main sets of indicators can be developed:

- ***Normalized exposure at risk (NEAR):*** provides the total percentage of the banks' portfolio which is at risk, by weighting each exposure towards each counterparty through a financial risk ratio. NEAR has the main objective of linking the Expected Annual Losses (EAL) to various types of environmental hazards. Currently data available is not sufficient to link EAL to all hazards, but is completely available to assess the correct impact of windstorms and flooding, which will be the hazard taken as example over the next paragraph.
- ***Potential Exposure at risk (PEAR):*** provides the percentage of the portfolio which is exposed to physical risks, based on all the exposures which have a risk greater than zero. PEAR is to be used to complement the NEAR by providing a potential maximum value for losses
- ***Risk scores (RS):*** provides further components to complement the PEAR by splitting the risks among different risk level categories.

Data sources for which data is actually available (such as flooding) include the European Commission's Disaster Risk Management Knowledge Centre (DRMKC), which is part of the Joint Research Centre (JRC). The JRC itself is also the body which has developed the damage function (which will be better explained later) to link hazards to the EAL.[84]

For what concerns windstorms, data can be gathered from the historical data provided by the wind speed dataset of the Copernicus Climate Change Service.

For other type of hazards, such as wildfires, data is not currently available from public data sources, however the JRC and the Copernicus Climate Change Service have developed framework to enhance the data collection process, such as the Fire Weather Index which slows to detect areas that contain highly flammable substances.

[84] ECB, Statistics Committee of the European System of Central Banks (January, 2023), *Towards climate-related statistical indicators*

In this context, statistical indicators have to be applied judiciously in order not to overestimate or underestimate the actual impact of physical risks involved. Overestimation can be verified as in some cases statistical indicators may not take into account the application of mitigation and adaptation measures, such as the creation of levees to reduce flooding risk. On the other hand, also underestimation of risk can be materialized for instance when in the assessment of a total physical damages, collateral assets are not taken into consideration. Thus, analytical indicators or proxies have always to be supported by explanations.

Over the following years, supervisory authorities will continue to develop frameworks in order to be able to provide future statistical indicators up to 2050 for every kind of environmental hazard.

3.1.2 Analytical indicators on transition risk

The analytical indicators developed for the assessment of transition risk are related towards two different goals: first, for assessing the actual emission financed by banks, and second for determining the actual exposure of financial institutions to carbon-intensive sectors.

Therefore, the analysis carried out over this paragraph will be split into two main parts according to the two perspectives just outlined.

First, it will be analyzed the indicators regarding emissions financed by banks. These indicators help assess the contribution of financial institutions towards carbon-intensive sectors. This can be done by linking the emissions produced by non-financial enterprises to its financing entities by examining identifiable securities and financing portfolios.

More precisely, in this context the Statistics Committee of the European System of Central Banks has developed two main indicators:

- **Financed Emissions (FE): "**Total greenhouse gas (GHG) emissions of a debtor/issuer weighted by the investment as a share of the company's total value."
- **Carbon Intensity (CI):** "FE divided by the production value of the company weighted by the investment in the company's activities as a share of the company's total value."[85]

The main downside of these two indicators is that they do not provide information on whether banks' financing aim at supporting a greener transition or not, rather they just show the contribution of their financing to GHGs emissions and can be used as a tool to set targets for emission reductions.

Second, the focus will be moved on the total exposure of financial institutions with respect to transition risk. To assess the exposure, this time the analysis will start from the financing portfolios,

[85] ECB, Statistics Committee of the European System of Central Banks (January, 2023), *Towards climate-related statistical indicators*

in particular of loans and securities towards carbon-intensive sectors. It is worth remarking that currently the only progresses that have been made regard *Scope 1* and *Scope 2* emissions, while significant blind spots persist around the collection of *Scope 3* emissions. This is one of the main reasons because of which the processes for the assessment of transition risk are still at an initial stage. Also with respect to the assessment of banks' exposure, it has been developed two main analytical indicators. The main difference of these indicators with respect to *Financed Emission* and *Carbon Intensity* is that previously the starting point was the corporation's emissions, while for these new indicators the standardization variable is the financing portfolio of banks.

- **Weighted average carbon intensity (WACI):** "Total GHG emissions of a debtor/issuer standardized by a measure of company production value, weighted by the investment in these activities as a share of the total investment portfolio value."
- **Carbon Footprint (CFP):** "FE standardized by the total investment portfolio value."[86]

All of the four analytical indicators which have been explained are in line with the recommendations issued by the TCFD under the 'metrics and targets' area.

Still, data on emissions keeps being the most problematic information to be gathered for the assessment of climate-related and environmental risks. This is because, as already repeated, data related to different sectors and countries and, above all, gathered through different methodologies, cannot be considered reliable and comparable. The main source of data for what concerns the previously analyzed indicators and loans granted to entities inside the European Union is the Eurosystem's AnaCredit dataset, while for what concerns emissions data (especially on *Scope 1* and sometimes on *Scope 2* emissions) the main sources are private datasets, namely mainly from Institutional Shareholder Services (ISS), supported by Refinitiv.

Further work will be done to find a way to develop a common framework for the correct assessment of *Scope 3* emissions: till then, it will be nearly impossible to properly assess the value linked to transition risk. The last paragraph of this paper will outline some of the last practices and organizations developed to try to at least mitigate this challenge.

3.2 Physical Risk assessment

The previous paragraph aimed at introducing some of the newest practices that financial institutions implement in response to the increased risk related to climate change. Among them, for what concerns particularly physical risk, significant progresses have been in the process of mapping

[86] ECB, Statistics Committee of the European System of Central Banks (January, 2023), *Towards climate-related statistical indicators*

risks in terms of the geolocation of physical assets. The following analysis will regard the risk posed by flooding on a mortgage portfolio, and will provide a more detailed description on the actual practices that banks have in place to evaluate the impact of physical risk.

3.2.1 Example of flooding risk on a mortgage portfolio

With the support of a technical paper published by Intesa Sanpaolo alongside Prometeia, the following paragraph will try to give a more detailed presentation of how to assess the impact of flooding risk on a mortgage portfolio. The choice to include an analysis of flooding risk is not casual, rather it represents the alternative for which there is the greatest amount of data at disposal, as previously introduced. On top of that, flooding risk is one of the most relevant among all environmental hazards because of the frequency and harmfulness of its related events, which is why the ECB has given much importance and included this source of physical risk on the bottom-up stress test conducted in 2022.

Moving to the risk analysis, it is important to note that the methodologies implemented for the risk assessment are the same that were previously outlined, namely: *exposure identification*, *hazard measurement* and *vulnerability assessment*. The combined analysis of these three components will lead to an expected impairment of the buildings concerned under the three reference scenarios provided by the NGFS[87]. Consistently with the NGFS scenarios, the time horizon considered is up to 2050. The last step will be to recalculate the portfolio impairments with the stressed *Probability of Default (PD)* and *Loss-Given Defaults (LGD[88])*, for which the relative data is provided by the performance of the three scenarios.

The risk analysis begins by putting into practice the three aforementioned methodologies:

1) ***Identification of exposure:***

The portfolio considered consists of 8,835 mortgage-backed buildings located in Italy. In order to identify the bank's exposure, data gathered will regard the location of the buildings alongside their implied initial value, plus more technical information regarding the guaranteed amount and the LGD of the concerned exposure, and the PD of the entrusted counterparty. In the portfolio considered, each exposure (i.e. each mortgage security) is guaranteed by a single residential property. In the considered context, the representation of exposures will be made accordingly to the methodology proposed by the ECB in its 2022 climate stress test, that is a representation based on the division of aggregated exposures with regard to their risk cluster. The table displayed below will provide a graphical clarification of what has just been described.

[87] Recall: the three scenario involved are the *orderly transition*, the *disorderly transition*, and *the hot house world* scenario

[88] LGD is a risk measure that provides the share of an asset that is lost if a borrower defaults

Flood Risk	Amount	#	Share (amount)
MINOR	683.217.576	3.547	43,0%
LOW	420.567.848	2.646	26,5%
MEDIUM	476.561.005	2.599	30,0%
HIGH	8.189.243	43	0,5%
TOTAL	1.588.535.672	8.835	100,0%

Table 1[89]: Breakdown of Italian properties by ECB risk bands

The residential properties for which the banks' exposure has been identified, have been previously geolocalized in terms of their latitude and longitude. In fact, their allocation along the different risk cluster is mostly dependent on their proximity to waterways.

In order to ensure full comparability among data and outcomes, the risk parameters PD and LGD have been homogeneous for all the exposures considered, thus any difference in their value is entirely related to flood shocks.

2) Hazard measurement

This step entails the estimation of flood risk, which can be broken down along two steps. First, the rainfall forecasting is estimated at individual property level based on the geographic cells where they are located, and long-term projections are gathered thanks to an IAM model[90] developed by Prometeia. The data gathered will allow the creation of specific equation which will be calibrated into the three NGFS reference scenario values.

Once the rainfall forecasting has been estimated, it will have to be estimated the flood depth to assess the actual impact of flooding extreme events. The concerned events will be forecasted with a high granularity in terms of geolocation, since the geographic cells developed cover areas of $1km^2$. Then for each cell and under each scenario it will be forecasted the likeability of extreme flooding events with the support of a probability distribution calculation process. The probability distribution of flood depth is calibrated accordingly to the main global hydrogeological models[91] and refers mainly to river flooding. Then, from the probability distribution, five return periods were identified and isolated, regarding time horizons of 10, 50, 100, 200 and 500 years.

[89] Source: Bartolucci L., Luciano Genero G., Pierigè M., Verachi F. (August, 2022), Risk Management Magazine – *Estimation of flood risk on a residential mortgages portfolio*, Prometeia, Intesa Sanpaolo

[90] The Integrated Assessment Model (IAM) refers to a scientific modelling framework that aims at linking economic indicators to environmental impact on the biosphere

[91] Such as HadGem2 Model

3) Vulnerability assessment

This process starts with the translation of the estimated flood depth into damages for the analyzed properties. The effective damage is represented as a structural depreciation on the residential properties, which can be assessed thanks to a damage function developed by JRC at European level. Such quantification of damages takes into consideration several aspects and characteristics of the property involved, as the location of the property, the related reconstruction costs, the vulnerable surface area and the maintenance status. In case some of these data are missing, at European level models are available for ensuring a collection of analytical indicators for fulfilling at least a minimum information set. Besides that, damage data is projected over the time horizon of the NGFS scenarios thanks to property price forecasting models, integrated with the IAM models previously cited.

Then, once the value of the damage has been forecasted, it is translated into a percentage of devaluation thanks to a mathematical model.

Data on percentage devaluation is fundamental to compute the Average Annual Loss (AAL), which is the expected write-down at portfolio level. The formula for computing the AAL is displayed below:

$$AAL_t\% = q_{sv}^{RP_{500}} p_{RP_{500}} + q_{sv}^{RP_{200}} p_{RP_{200}} + q_{sv}^{RP_{100}} p_{RP_{100}} + q_{sv}^{RP_{50}} p_{RP_{50}} + q_{sv}^{RP_{10}} p_{RP_{10}}$$

Formula 1: Calculation of expected Average Annual Loss

The formula shows that the AAL is given by the multiplication of the percentage devaluation over each of the 5 return periods identifies times the respective probability of occurrence.

Following the assessment of the Average Annual Loss, which represents the first milestone in the process of evaluating the impact of physical risk, it will have to be assessed the impact of such risk on the two main risk parameters, namely the *Loss Given Default* and the *Probability of Default*.

Starting from the forecasted property depreciation previously outlined, the stressed LGD is calculated for each single property, based on the forecasted cumulative depreciation on the asset relative to its beginning value. The following step is to aggregate the individual values according to the risk clusters suggested by the ECB and for each NGFS reference scenario, as it will be shown in the tables below.

ORDERLY	2021	2030	2040	2050
1	13,5%	13,5%	13,5%	13,5%
2	13,5%	13,5%	13,5%	13,5%
3	13,5%	13,7%	13,7%	13,8%
4	13,5%	14,7%	15,7%	16,8%

DISORDERLY	2021	2030	2040	2050
1	13,5%	13,5%	13,5%	13,5%
2	13,5%	13,5%	13,5%	13,6%
3	13,5%	13,7%	13,8%	14,0%
4	13,5%	15,1%	16,1%	17,4%

HOT-HOUSE	2021	2030	2040	2050
1	13,5%	13,5%	13,5%	13,5%
2	13,5%	13,5%	13,5%	13,7%
3	13,5%	13,7%	13,9%	14,1%
4	13,5%	15,1%	16,4%	17,9%

Tables 2,3,4[92]: Stressed LGD by scenario

These output tables show the percentage value of LGD for each intermediate time up to 2050, and for assets assigned to each risk cluster under all of the three NGFS reference scenarios. Numbers on the left of the tables ranging from 1 to 4 represent the relative risk cluster, where 1 represents negligible risk and 4 represents high risk. Therefore, by looking at the outputs of the table, it can be seen that the most significant LGD stress intensity is concentrated around risk cluster 4. Another relevant finding is that the outcomes of the *disorderly transition* and the *hot house world* scenario show significant similarities.

The last risk parameter which has to be assessed is the *Probability of Default (PD).* Also with respect to the PD, the relative analysis has to be performed on the basis of the three NGFS reference scenarios. In terms of probability of default, the impact of flood events is calculated through a formula that correlated PD to LGD. Even though this field is supported by relatively low amount of data,

[92] Source: Bartolucci L., Luciano Genero G., Pierigè M., Verachi F. (August, 2022), Risk Management Magazine – *Estimation of flood risk on a residential mortgages portfolio*, Prometeia, Intesa Sanpaolo

empirical evidence shows that extreme flooding events cause a deterioration in the credit quality of individual borrowers for mortgage-backed properties.

The formula used in the paper by Intesa Sanpaolo and Prometeia is the Frye-Jacobs model:

$$PD_{ST} = \frac{\Phi\left[\Phi^{-1}[PD_{ST}] - \frac{\Phi^{-1}[PD_{TTC}] - \Phi^{-1}[PD_{TTC} \cdot \mathrm{LGD}_0]}{\sqrt{1-\rho}}\right]}{LGD_1}$$

Formula 2: Frye-Jacobs model on credit loss and systematic LGD

The implementation of the Frye-Jacobs model allows the creation of output tables showing the value of PD for each risk cluster under each of the NGFS reference scenarios, as it was for the LGD assessment.

The tables displaying the underlying PD information are displayed below:

ORDERLY	2021	2030	2040	2050
1	0,67%	0,67%	0,67%	0,67%
2	0,67%	0,67%	0,67%	0,67%
3	0,67%	0,72%	0,72%	0,75%
4	0,67%	1,00%	1,33%	1,79%

DISORDERLY	2021	2030	2040	2050
1	0,67%	0,67%	0,67%	0,67%
2	0,67%	0,67%	0,67%	0,70%
3	0,67%	0,74%	0,75%	0,79%
4	0,67%	1,13%	1,49%	2,06%

HOT-HOUSE	2021	2030	2040	2050
1	0,67%	0,67%	0,67%	0,67%
2	0,67%	0,67%	0,69%	0,73%
3	0,67%	0,74%	0,77%	0,84%
4	0,67%	1,13%	1,61%	2,34%

Tables 5,6,7[93]: Stressed PD by scenario

[93] Source: Bartolucci L., Luciano Genero G., Pierigè M., Verachi F. (August, 2022), Risk Management Magazine – *Estimation of flood risk on a residential mortgages portfolio*, Prometeia, Intesa Sanpaolo

Even for PD data, it is clear by looking at tables 5, 6 and 7 that the most severe impacts of extreme flooding events are on cluster 4. Again, the *disorderly transition* scenario and the *hot house world* scenario provide similar results. The peculiarity of this analysis with respect to the LGD analysis is that the difference between the initial PD value (i.e. 2021 value) and the final value in 2050 presents a great shift. Even in the case of the *orderly transition* scenario, the PD relative to cluster 4 in 2050 is almost three times the PD in 2021. This provides an indication that, no matter what policies will be implemented to tackle climate change, the impact of extreme flooding events (and physical risk in general) will rise over the next decades and cause increased damages also on banks' credit portfolios.

The last step of the physical risk assessment provides the integration of the risk indicators just analyzed into the projected financial statements of banks. In this context, some banks are able to develop a dynamic balance sheet to be adjusted for the outcomes produced such as the depreciation impairments, even though this practice requires the establishment of highly developed and specific internal risk management frameworks. What almost all banks can and are actually doing in this regard, is to assess the impact of risk indicators such as PD and LGD on banks' revenues and interest income.

In conclusion, the main evidence from this analysis is that, at least at Italian level, the majority of the mortgage portfolio carry negligible flooding risk, while most exposed fraction of the mortgage portfolio represents a small part of it. Still, the impact of flood risk on the overall portfolio cannot be considered negligible, as it can be seen by tables from 2 to 7.

For what concerns any possible improvement on the methodologies just outlined, supervisory authorities and regulatory bodies will work on the development of new regulations and guidelines to allow banks to be able to progressively integrate physical risk assessment into their business strategy and governance, on top of their risk management frameworks. For sure, new regulations are needed for ensuring an adequate mapping of banks' exposure to physical risk. Furthermore, banks should progressively be required to put in place appropriate damage estimation methodologies with regard to climate risks, and to develop sets of forward-looking metrics and targets to keep track of possible climate impacts.

3.3 Transition risk assessment

As already explained over several paragraphs within this paper, transition risk represents the most problematic factor to be evaluated as it is complicated to precisely assess the actual exposure of financial intermediaries to transition risk. This is true since there is not yet a general, shared framework for assigning a precise value to the main indicators of exposure to transition risk. The underlying missing data refers to GHGs emission, particularly *Scope 3,* which are considered to be

the most significant source of carbon emissions, and the EPC of buildings, for what concerns both mortgage-backed properties and the warehouses and offices of banks' counterparties.

Still, as climate change is speeding up the transition process towards a greener economy characterized by renewables and sustainable practices, banks need to assess how they are exposed towards counterparties operating in sectors at high risk, that is carbon-intensive sectors.

Currently, the best practice that banks can put in place in order to ensure a proper administration of transition risk is to split the management of risk over two main procedures. First, a mapping of risks is fundamental to get an idea of the banks' actual exposure. Second, banks should develop appropriate practices depending on the specific situation in order to be at least partially shielded against climate risks. Briefly, they need to choose the optimal strategy to minimize the impact of their exposure to carbon-intensive counterparties.

3.3.1. Mapping

Even though banks cannot assess their exposure in terms of the exact quantity of counterparties' emissions or the EPC of their offices, banks should at least be able to identify the main sources of such exposure. In this regard, banks should push for reaching a portfolio alignment with respect to the climate targets set by supervisory authorities. Portfolio alignment refers indeed to the measurement of portfolios' carbon footprint, and the subsequent portfolio modification by reallocating capitals, disinvesting in GHGs-intensive sectors and engaging with clients to support their transition process.[94]

The metrics applied to gain an understanding of the counterparties' emissions include, where possible, the computation of the aforementioned *Financed Emissions (FE)* and *Carbon Intensity (CI)* and on top of those, the computation of the Economic Intensity (EI)[95].

After banks have broadly recognized their portfolio's financed emissions, they need to set future target emission trajectories based on their ambitions and compare them with trajectories of common reference scenarios. Lately, several organizations have indeed published alternative climate scenarios that identify the evolution of climate related variables (such as GHGs emissions) of several sectors under different assumptions. Among them, some of the most significant are the four scenarios published by the World Energy Outlook (WEO) in 2021:

1) *Net Zero Emissions by 2050 (NZE):* sets an ambitious path for the global energy sector to reach carbon neutrality by 2050.

[94] Source: Interviews conducted with Banca Sella

[95] EI is the value given by the FE divided by revenues produced by the counterparty

2) *Sustainable Development Scenario (SDS):* scenario based on increased policies and investments in clean energy. The underlying path aims to keeo global warming well below 2 Degrees Celsius with respect to pre-industrial levels.
3) *Announced Pledges Scenario (APS):* implies that all climate commitments (such as individual NDCs) are fully respected and that net-zero targets are met on time.
4) *Stated Policies Scenario (STEPS):* reflects current policies setting and assumes that no further policy is implemented.

Each of the four scenarios is characterized by an emission trajectory, that banks can use as a benchmark for the evolution of their financed emissions based on the individual targets set.

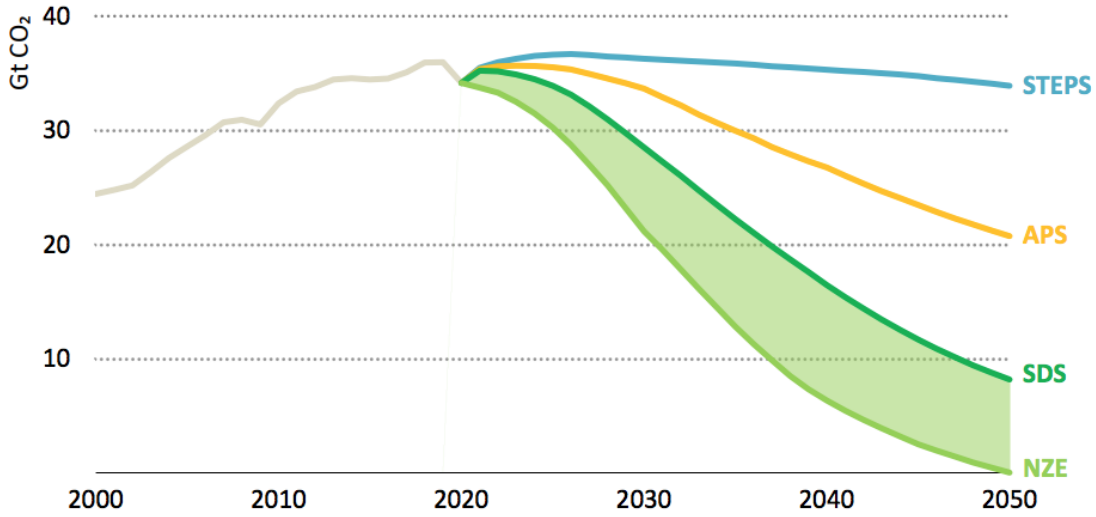

Figure 22[96]: CO2 emissions in the WEO-2021 scenarios over time

3.3.2 Strategy Implementation

After having identified the main exposures and developed targets on future financed emissions, there are a few strategic actions that banks can implement in order to green their portfolios. First, where possible, banks should carry out specific and targeted client engagement and support GHG-intensive counterparties in their transition processes through the offering of green financial securities and the implementation of credit policies in support of green transition.

In cases where the portfolio is too exposed to transition risk, instead, banks should implement strategies for the reallocation of financings towards more sustainable assets. For instance, they can increase their exposure towards top performers in ESG terms, or implementing phase-out or disinvestment policies for GHGs-intensive counterparties.

In response to the increased threats posed by transition risk, the United Nations Environment Programme Finance Initiative (UNEP FI) has driven the creation of the Net Zero Banking Alliance (NZBA). The NZBA brings together global banks committed to achieving the goals set by the Paris

[96] Source: IEA (2021), *World Energy Outlook 2021*

Agreement, and as of today accounts for more than 75 members across 35 countries for a total of $54 Trillion in assets, representing about one third of global banking assets. NZBA members must support the transition to a net-zero economy by 2050 through investment and financing policies. Concretely, the strategic objectives of the alliance are to develop frameworks for the collection of exact emission data, the offering of green loans, and the measurement of the climate-risk adjusted profitability based on climate scenarios.

More specifically, decarbonization targets are defined at sectoral level with respect to the most carbon-intensive industries: within 18 months of joining the commitment, banks must set targets for the identified emission-intensive economic sectors. Furthermore, within 36 months targets must be set for all economic sectors in NZBA perimeter.

Conclusion

This paper aimed at providing an overview of the current state of the financial sector with respect to the management and assessment of risks posed by climate change. Latest evidence shows that over the last few years supervisory and regulatory bodies, alongside financial institution themselves, have begun a process to concretely assess the impacts that physical and transition risk can have on banks' operations, and in turn on the financial system as a whole. In order to avoid severe financial disruptions, banks need to evaluate these risks and concretely support the transition towards carbon neutrality.

The analysis provided shows that banks have made progresses in the management of such threats. Especially for what concerns physical risk, the whole system has at least laid the foundation for the development of common risk management frameworks. However, these enhancements are mainly related to the actual assessment of only a subset of hazards (such as windstorms and flooding, as shown over paragraph 3.2.1), which implies that further progresses need to be done also in this specific area. Furthermore, significant blind spots persist instead on the actual evaluation of transition risk, mainly because it is still challenging to collect emission data to perform the needed analyses.

Thus, it is needed a combined effort by all the players operating in the financial system to collectively develop new methodologies for addressing the transition risk issue. The creation of the NZBA can be considered as a good example of cooperation among banks to address this problem.

However, this may not be sufficient. There is also urgent need by regulatory bodies to keep developing mandatory rules on the disclosure of emission by all players in the economy.

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