Network for Greening the Financial System

Technical document

Conceptual Note on Adaptation

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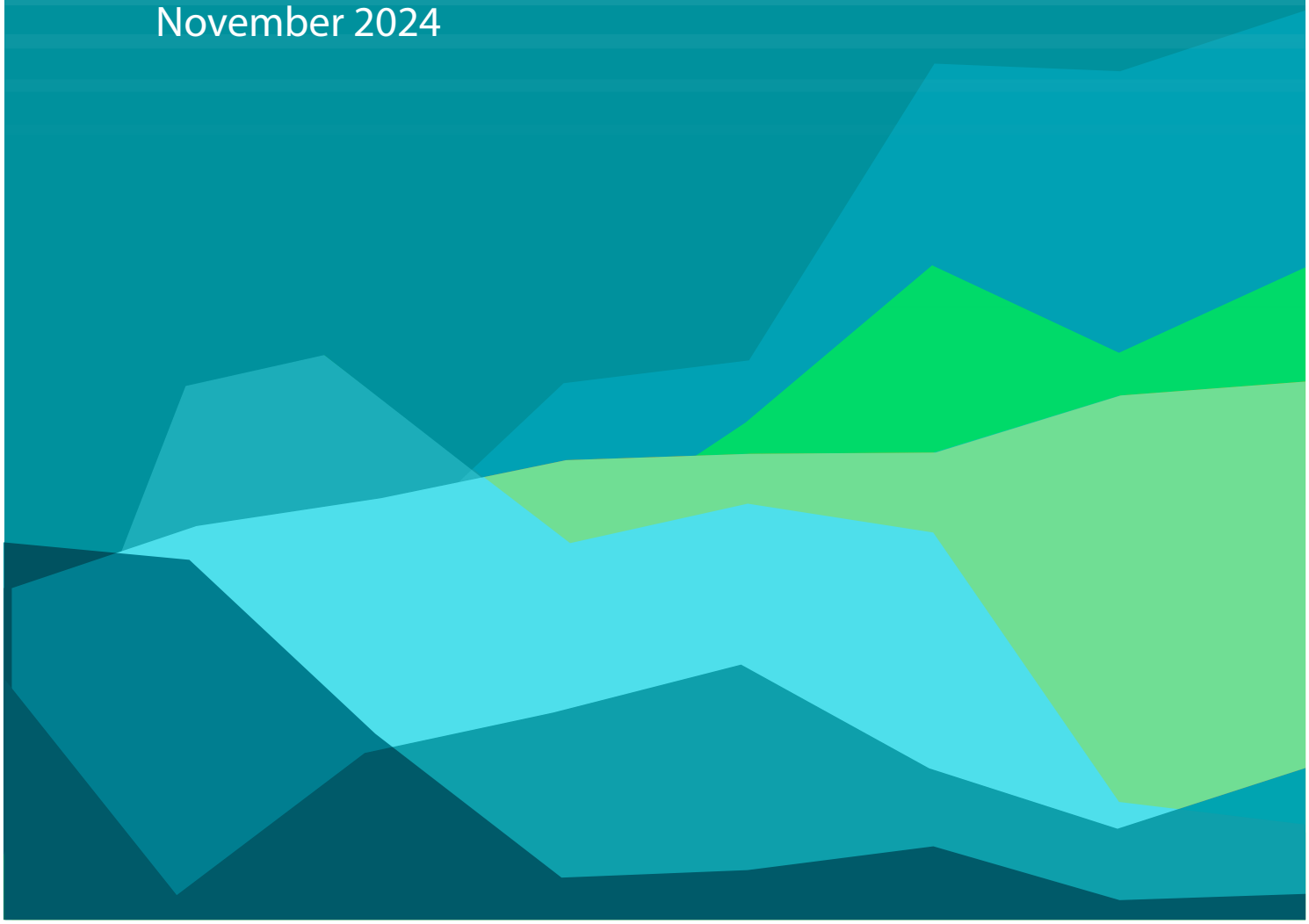

NGFS

Central Banks and Supervisors
Network for Greening the Financial System

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Climate change is one of the most pressing global challenges of our time, with impacts that are felt worldwide and necessitate urgent, coordinated action. While efforts to reduce greenhouse gas emissions remain critical, the accelerating impacts of climate change mean that adaptation has become an immediate priority especially in Emerging Markets and Developing Economies (EMDEs). The IPCC's recent findings underscore this urgency, with rising temperatures and frequent climate events requiring enhanced resilience across economies and societies.

As a global coalition of central banks and supervisors, the Network for Greening the Financial System (NGFS) has advanced climate action within the financial sector. To date, this work has primarily focused on mitigation. In response to the growing urgency of acting on climate adaptation, this Conceptual Note marks the first comprehensive exploration by the NGFS of climate adaptation and its implications for financial stability. It highlights the importance of integrating adaptation into risk management, promoting adaptation finance and bridging insurance protection gaps, for both developed economies and EMDEs.

This publication is an exploratory work that aims to make the case that central banks and supervisors should consider climate adaptation to climate change within the context of their mandates of price and financial stability. It also sets out critical areas for further and deeper analysis, including the need for robust metrics, enhanced policies and supervision, and strengthened international collaboration. Developed with valuable insights from NGFS members and key stakeholders, this Conceptual Note seeks to lay the foundations that will help equip central banks and supervisors to support climate adaptation effectively and collaboratively.

We extend our gratitude to all contributors, and we hope this note will serve as a practical resource for central banks and financial supervisors worldwide as we work collectively towards a resilient and adaptive financial system.

Executive Summary

Climate adaptation and the financial system

Global temperatures have been rising due to continued greenhouse gas emissions. According to the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6), global surface temperatures were 1.1 °C above pre-industrial levels (1850-1900) over the period 2011-2020. Rising temperatures have already led to widespread and rapid changes in the biosphere, and inertia in the Earth's climate system means that even with rapid and immediate emissions reductions these climate effects will persist for the foreseeable future.

Physical risk from climate extremes will make timely and effective adaptation to climate change a necessity. The IPCC defines climate adaptation as the adjustment of natural or human systems in response to actual or expected climate change. With global emissions continuing to rise, the urgency and scale of need for communities, industries and nations to adapt to a changing climate will continue to increase.

However, current adaptation efforts remain insufficient, highlighting the importance of the financial system in managing the associated physical climate risks, and mobilising capital to support the necessary investment. The pace of progress in climate adaptation and finance needs to keep pace with the escalating impacts of climate change (UNEP, 2023): this has major implications for the actions of central banks, financial regulators and supervisors, as climate change poses significant challenges to monetary and financial stability.

The role of the NGFS and the purpose of this Conceptual Note

The Network for Greening the Financial System (NGFS) helps to enhance the role of the financial system in managing risks and mobilising capital for green and lower-emissions investments consistent with environmentally sustainable development. It recognises that the impacts of climate change will be far-reaching in breadth and in magnitude, subject to tipping points and irreversible changes. These impacts are uncertain and yet at the same time totally foreseeable. Crucially, the NGFS has argued that the size and balance of these future financial risks and economic costs will depend on the actions we take today (NGFS, 2020b). This Conceptual Note explores the opportunity for adaptation to account for a larger part of the actions taken today.

The NGFS can contribute to the global collaborative effort to scale up climate adaptation, to promote monetary and financial stability and enhance economic and financial resilience. The technical discussions and areas for consideration outlined in this note draw on past NGFS work on environmental risk analysis by financial institutions (2020a), scaling up green finance (2022), climate scenarios for central banks and supervisors (2023a), acute physical risks and their impact on monetary policy (2024a), transition plans (2024b), and climate-related disclosure (2024c). In 2023, the NGFS published *Scaling Up Blended Finance for Climate Mitigation and Adaptation in Emerging Markets and Developing Economies* (2023b), which provided recommendations aimed at addressing key barriers to scaling blended finance in EMDEs. Up until this point, the work of the NGFS had focused on climate change mitigation. In this publication, however, it was acknowledged that the relevance and importance of climate adaptation was becoming increasingly clear as physical risk events caused by climate change become more commonplace, even as actions are taken to reduce greenhouse gas emissions. Countries around the world are already experiencing negative economic and financial impacts from both the acute and chronic effects of climate change. This makes the need for better adaptation to climate change more urgent than ever. In recognition of this, the NGFS has set out to build on this publication and consider further work on adaptation issues, where it can possibly add value and offer complementary views. This Conceptual Note is the first contribution of the NGFS on this topic.

This note makes the case for the importance of considering adaptation to climate change within the mandates of central banks and supervisors. In particular, it underscores the risks that the financial system and its regulators face from failing to adapt to a changing climate, including the need to foster adaptation finance and

to address insurance protection gaps. This note explores the topic of adaptation to climate change to better understand the relevance and importance of adaptation to both chronic and acute effects of climate change for central banks and supervisors. Given the range of interpretations of the scope and meaning of climate adaptation, this note provides definitions to anchor the discussion. It also complements the NGFS core work of supporting its members in assessing the macroeconomic and financial stability implications of climate change and adjusting their policy actions accordingly. In identifying areas for further work, the note acknowledges varying mandates of central banks and supervisors in different jurisdictions as well as the differing national circumstances (particularly for developed versus emerging economies).

The Conceptual Note begins with a presentation of the costs and benefits of adaptation (Section 1) and proceeds to describing the importance of adaptation as a form of risk management for the financial system and society more broadly (Section 2). It explores the challenges facing efforts to scale up adaptation financing (Section 3). Finally, this note outlines considerations for future work to be conducted by the NGFS, central banks and supervisors (Section 4). Several national case studies are included to showcase specific actions being taken by regulators, both individually and in collaboration with other public and private sector groups (Annex).

Central Banks, Supervisors and Adaptation

Potential economic losses and price fluctuations that could arise due to a failure to take action on adaptation are relevant to the price and financial stability mandates of central banks and supervisors. The economic costs of insufficient adaptation are significant, with extreme weather events linked to climate change already accounting for a reduction of approximately 1% of GDP per year on average for low-income countries between 2000 and 2019 (Newman and Noy, 2023). While the literature on the mitigating impact of adaptation on inflation and volatility is scarcer, studies point to significant impacts from climate shocks on inflation. For example, Peersman (2022) estimated that shifts in international food commodity prices between 1961 and 2016, caused by harvest shocks, explain 30% of euro-area inflation volatility in that period. Climate adaptation, which seeks to enhance socio-economic resilience, is therefore of direct importance to central banks (Mauderer, 2024). Encouraging adequate adaptation will also result in broader economic and socio-environmental (non-market) benefits. While investing in adaptation has shown a high return on investment (Standard Chartered & al, 2024), an important hurdle to adaptation financing is that the benefits from investments are often for the common good, and they can be difficult to translate into cash flows. Investors may also not be well placed to prioritise their investments in companies or projects due to distributed benefits.

Central banks and supervisors also acknowledge that adaptation must be embedded in risk management practices, for financial and non-financial institutions alike. The economic and financial risks posed by climate change are the result of a complex interaction between the increase in climatic hazards and the exposure and vulnerability of society to those hazards. Both mitigation, which focuses on reducing greenhouse emissions, and adaptation, which focuses on reducing exposure and vulnerability to these hazards are forms of risk management. Supported by the work of the NGFS, central banks and financial supervisors have encouraged financial institutions to incorporate climate risks in their broader risk management practices. It is important that this involves consideration of adaptation as a risk management response as well as mitigation. This can include embedding adaptation in regulatory frameworks, transition plans, investment decisions, and climate scenarios. Much of the work on adaptation is focused on increasing physical resilience to climate hazards, but financial institutions will naturally have a role to play in supporting increased financial resilience. Addressing the insurance protection gap[1], for example, will play a key role: estimates indicate that in 2023, 60% of global exposures were uninsured (Swiss Re, 2024). Higher levels of insurance penetration can provide a level of financial resilience that can mitigate the economic impacts of extreme weather events, and the pricing of insurance[2] against natural perils can serve as a powerful mechanism

1 "Insurance protection gap" is defined as the difference between the economic value of the asset and the amount of insurance cover purchased.

2 This Conceptual Note uses "insurance" to refer to both insurance and reinsurance.

for encouraging the adoption of adaptation measures, therefore fostering a favourable environment for price and financial stability. Against this backdrop, it may be important for central banks and supervisors to consider the importance of insurance affordability and availability for the wider financial system. It is also important to ensure that adaptation finance is inclusive and effective, which requires well-designed and targeted financing mechanisms.

Central banks and supervisors can also contribute to scaling up the financing of adaptation. Current financing for investment in adaptation is limited: globally, around 4% of reported climate finance is for adaptation purposes, with around 98% of this financing originating from public sources (Buchner, 2023: cited in World Bank, 2024). The annual climate adaptation financing gap in developing countries is estimated to range between USD 194 billion and USD 366 billion, which is around 10-18 times more than current financing flows (UNEP Adaptation Gap Report, 2023). The gap may be attributed to several barriers including a lack of awareness, underdeveloped foundational market infrastructures (e.g. efficient capital markets, credit guarantee systems, sound development policies), the fact that benefits are distributed, and pricing may be uncertain, and uncertainty over the needs for adaptation and resilience. Ultimately, closing this gap is necessary to support price and financial stability, as per the mandates of central banks and supervisors. The NGFS and its members can continue to contribute to this effort by building on the insights presented in the report on *Scaling Up Blended Finance for Climate Mitigation and Adaptation in Emerging Markets and Developing Economies* (2023b).

Although impacts of climate change are seen worldwide, emerging and developing economies are the most severely affected by climate events, and their governments generally have more limited financial resources which are also stretched by dealing with other priorities (e.g. health, education, employment), leaving them with very limited capacity to finance adaptation projects. According to analysis from the World Bank Country Climate and Development Reports (World Bank, 2023), in some countries, unmitigated climate change could reduce GDP by more than 12% by 2050 against a baseline scenario. EMDEs also face a substantial climate financing gap, particularly for adaptation (World Bank, 2024). Only 14% of climate finance flows reach EMDEs other than China, predominantly for mitigation purposes. Countries from the Latin America & Caribbean region receive only about 4% of global climate finance flows, with little going to adaptation (12.5% of total flows).

The exploration of climate adaptation in this note has confirmed the importance of this topic to central banks and supervisors and has identified numerous actions that can be taken in response. Four key areas where further work can be conducted by authorities are:

- Role of metrics and tools for better measurement and disclosure of adaptation.
- Exploring the need to enhance policy, supervisory and regulatory frameworks.
- Fostering an enabling environment for adaptation finance.
- Collaborating at the international level, with actions focused on local considerations.

1. Adaptation and its linkages to the mandates of central banks and supervisors

1.1 Defining climate adaptation and resilience

To most effectively explore climate adaptation and the role of central banks and supervisors in supporting effective climate adaptation measures, it is useful to begin with clear definitions of the terms adaptation and resilience.

While other definitions may exist and be used by other institutions, the IPCC defines adaptation as:

The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Adaptation can occur reactively to change and disruption, or it can be a planned, deliberate response to pre-emptively take preventive measures to reduce exposure and vulnerability to climate risk that will be experienced in different ways in different countries, societies and ecosystems.

Successful adaptation measures improve the resilience of communities, businesses, financial institutions, the economy and the financial system to the impacts of climate change.

The IPCC defines resilience in the context of climate change as:

The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

An important type of climate adaptation involves increasing physical resilience, but efforts to improve financial resilience are also crucial, and this is an important issue for central banks and supervisors to consider alongside climate adaptation. While resilience is a state, adaptation involves change. While climate adaptation will often involve hardening infrastructure to increase resilience, where infrastructure is already resilient, adaptation may not be required. These are *preventive* measures to reduce the impact of climate events, such as the construction of tidal barriers to protect against storm surge inundation. However, it is also important to consider measures such as social safety nets and insurance, which help people, institutions and communities *recover* more effectively when the impacts of climate change are realised. Widespread insurance protection gaps highlight the need to improve financial resilience. Although not commonly given the label "adaptation", improving financial resilience to climate events is an important topic for central banks and supervisors. Successful adaptation, taken here in the broader sense of improving both physical and financial resilience, aligns strongly with the financial stability outcomes sought by central banks and supervisors globally.

According to the United Nations Framework Convention on Climate Change's (UNFCCC) *Fact Sheet on the Need for Adaptation*, there are many options for climate adaptation, including technological options such as measures to flood-proof houses, behaviour change at the individual level, such as restricting the use of water in times of drought, early warning systems for extreme events, improved risk management, natural peril insurance options, biodiversity conservation to reduce the impacts of climate change on people, e.g. by conserving and restoring mangroves to protect people and property from storm surges.

To identify which activities constitute adaptation finance, it is important to understand the objective of these activities and whether they support climate adaptation objectives. This paper covers three main types of adaptation and resilience finance activities:

- **Activities for which adaptation is the main purpose.** These activities are generally undertaken to manage physical risk by reducing exposure and vulnerability to natural hazards and extreme weather-related events. Examples of this include building flood levees and sea walls to reduce the risk of flooding. As this is the most widely used interpretation of adaptation, most of the data and statistics on adaptation finance refer to this type of adaptation activity.
- **Activities that are adapted to climate change,** with integrated measures to manage physical risks. The financial sector is already funding infrastructure

development that, while not undertaken with the primary objective of adaptation, involves construction to standards that ensure resilience not only to current but also to future climatic conditions (Fankhauser, S *et al.* 2023). Since these activities assist in minimising the direct impact of the natural hazard then, they can be considered to be a form of adaptation finance despite not being consistently categorised and tracked as such. Recognising the role of adapted activities highlights that mechanisms such as climate-aware building and lending standards can also support the expansion of adaptation finance.

- **Activities that enable adaptation** and contribute to reducing vulnerability to climate change such as through supporting knowledge sharing, technological advancements and capacity building.

These categories closely align with other published classifications of adaptation measures and activities, such as that of the Climate Bonds Initiative's Resilience Taxonomy (2024). It distinguishes four categories: (i) *adapting measures* that make the activities in which they are implemented more climate resilient (e.g. the use of leak detection equipment), (ii) *adapted activities* that are fully adapted and resilient to all material climate risks (e.g. the renovation or management of water supplies to make them more resilient to water stress), (iii) *enabling measures* that are implemented within an activity to make other activities more climate resilient (e.g. the extension of water supplies to water-stressed locations), and (iv) *enabling activities* that make other activities more climate resilient, as well as being themselves climate resilient (e.g. the manufacturing of leak detection equipment for use in water supplies). Adapting and adapted activities correspond to the first two categories above, while the third category above combines enabling measures and enabling activities.

Activities may not fit entirely into a single category and may combine direct and enabling characteristics. Activities may also have **shared objectives of adaptation and development,** where adaptation is one of the objectives of these activities but not the only one. While this Conceptual Note focuses on adaptation to climate change, much of the terminology presented here as well as the discussion in later sections can also be applied to adaptation to other types of environmental threats such as biodiversity loss.

1.2 Pathways and interlinkages

In order to understand the implications for central banks and supervisors of the imperative for adaptation to climate change, it is useful to have a framework for articulating the pathways from climate change to physical risk events through to economic and financial impacts. This framework provides a foundation for bringing the risk management perspective to adaptation that is outlined in Section 2. Section 4 also builds upon this foundation to draw conclusions on the aspects of climate adaptation of most relevance for the NGFS and its members.

The acute and chronic physical effects of climate change present risks to the value of certain assets and income streams (Reserve Bank of Australia, 2023 and NGFS, 2022), **and directly and indirectly impact communities, businesses and the broader economic environment, thereby creating risks for the financial system as a whole.** This transmission effect from the physical sphere to the economic one has been extensively discussed in previous NGFS publications (NGFS, 2020a). Climate adaptation measures include increasing physical resilience to natural perils and, considered more broadly, can also encompass efforts to increase financial resilience.

The economic impacts of climate change in turn present a range of financial risks, including affecting credit risk (e.g. through the risk of impairment of physical collateral), market risk, underwriting risk and operational risk. At sufficient scale, climate risks posed to business activities or to customers present strategic risks.

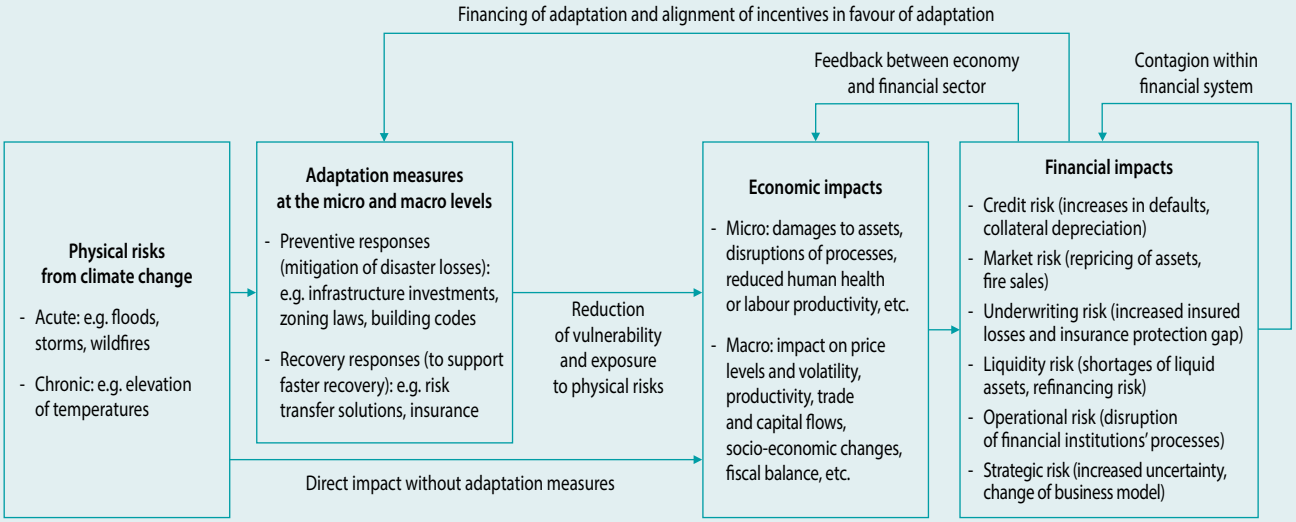
Adaptation measures aim to reduce the physical and thereby the economic and financial risks of climate change. An example of a macro level measure is the Netherlands' Delta Program (see Annex) which protects communities against storm surge inundation. At a macro level, large-scale strategies implemented by governments – including planning, regulation and standard-setting functions of government – businesses and communities to address the impacts of climate change can be activities such as upgrades that improve the resilience of infrastructure to climate perils, or adapting urban planning to recognise and pre-empt future climate risk. At the micro level, complementary and individualized adaptation measures such as home insulation, or improved flood and wildfire resilience,

can materially improve the resilience of assets at a household level. The role of finance in adaptation extends beyond specific adaptation projects, such as dams, levees or tidal surge barriers (activities with adaptation as the main purpose), and includes a broad range of infrastructure developments, such as roads, bridges and buildings which are constructed to standards which will ensure their resilience in the face of a changing climate (activities which are adapted to climate change).

While greater financial resilience, including through adequate insurance, can help in responding to the adverse effects of climate change, improving physical resilience can also foster financial resilience, and thus the broader resilience of the financial system (Figure 1).

For instance, from a physical perspective, communities, businesses and supply chains become more resilient to the impact of climate perils where infrastructure has been adapted to meet current and future climate risks. The return on investment for such adaptation measures is the absence or reduction in future business interruption, reinforcing financial resilience. Similarly, the lack of physical resilience can negatively impact the financial resilience of economic actors. For instance, in the absence of proper adaptation policies, the economic cost of financial disasters will be higher, including for insurers, which in turn leads to higher insurance premiums. As the cost of insurance increases, policies may become unaffordable for some individuals, and lead to worsening protection gaps.

Figure 1 **Financing of adaptation measures reduces vulnerability and physical risk exposure**



Source: Adapted from Svartzman, R. et al., (2021), A "Silent Spring" for the Financial System? Exploring Biodiversity-Related Financial Risks in France.

The finance industry can provide financial resilience to climate events in a number of ways. This includes disaster relief measures (such as offering loan hardship concessions to affected customers), affordable and accessible insurance, adaptation support funds, to both support and promote adaptation and resilience activities and offer a financial safety net and pathway to recovery after an event (e.g. through insurance payouts)**.** As the climate changes, there will be a need to enhance these types of measures to provide greater financial resilience.

1.3 Economic costs of insufficient climate adaptation

The economic costs of insufficient adaptation to climate change are significant. Even with global warming below 1.5 °C, the risks associated with climate change are increasing rapidly, and it has already resulted in loss of lives and serious impacts on livelihoods according to Standard Chartered/KPMG/UNDRR (2024). According to Newman and Noy (2023), extreme weather events3 linked to climate change already accounted for approximately 1% of GDP per year on average for low-income countries between 2000 and 2019. In some EMDEs, unmitigated climate change could reduce GDP by more than 12% by 2050 against a baseline scenario (World Bank, 2023).

The costs of inaction are large and will likely far exceed the costs of acting (UNEP, 2022). The total cost of inaction from 2025 to 2100 could be as high as USD 1,266 trillion[4]. The 32 million individuals at risk of falling into poverty by 2030 due to climate change are also likely to be part of the human toll of insufficient adaptation.[5]

Insufficient adaptation can be expected to impact price and financial stability, creating new challenges for central banks and supervisors. For example, disruptions in supply chains and damage to infrastructure (such as ports with relatively low sea barriers) caused by physical shocks may trigger higher volatility in inflation. Several studies establish a link between climate shocks and inflation levels and volatility, but the literature on the importance of adaptation is still scarce. Peersman (2022) estimates that shifts in international food commodity prices between 1961 and 2016, caused by harvest shocks, explain 30% of euro-area inflation volatility. In a case study of Germany, McDermott and Nilsen (2014) estimate that electricity prices increase by about 1% for every 1% fall in river levels and 1°C increase in water temperature above 25 °C. Ciccarelli *et al.* (2023) find mixed effects: they estimate that when the monthly mean temperature increases by 1 °C in the summer, unprocessed food inflation rises by around 0.1-0.2 percentage points within the first year after the shock. However, a shock occurring in the winter or spring has less significant impacts and can lead to a fall in inflation, though the effect is usually less persistent than when the shock occurs in the summer.

How inflation volatility changes over time will depend on adaptation and mitigation efforts. In the near term, these efforts may place upward pressure on inflation during the transition. However, in the medium term, these efforts would be expected to lower inflation volatility driven by extreme weather events in the future. Inflation will likely become harder to interpret and forecast, and the way inflation expectations are formed may change (Buelens C., 2024). Some research suggests that future adaptation measures offer an opportunity to substantially reduce inflation uncertainty from climate change. However, without considerable climate change mitigation efforts, pressure on inflation would remain persistent and sizeable (Kotz M. *et al.* 2024). Understanding how adaptation measures impact inflation and economic stability, especially through tools like climate-integrated forecasting, can offer valuable insights for central banks as they assess the inflationary pressures linked to climate events.

3 Terms such as "extreme weather events" (which is used both for chronic and acute events), "physical risk events", "natural disaster" and "natural catastrophe" are used interchangeably in this Conceptual Note. Since a natural hazard only becomes a disaster if it impacts a community that is exposed to the hazard without adequate protection, some argue against the use of the terms "natural hazard" or "natural catastrophe". The NGFS acknowledges the UNDRR campaign on #NoNaturalDisasters (https://www.undrr.org/our-impact/campaigns/no-natural-disasters), but made the decision to keep this language in this Note in recognition of their widespread use, and to keep it consistent with commonly used wording in other NGFS publications, such as the Report on "Acute physical impacts from climate change and monetary policy".

4 Climate change presents a major risk to infrastructure, as higher sea levels, more frequent extreme weather events, and rising temperatures can all contribute to the degradation of infrastructure. According to current climate projections, the potential impacts on infrastructure are significant. Estimates based on current climate conditions and policy outlooks suggest that by 2050, infrastructure assets could experience an average net value decline of 4.4%, with the possibility of up to a 26.7% decline in the most severe scenarios due to the escalating physical risks associated with climate change. This devaluation is a direct result of the insufficient resilience of global infrastructure to the impacts of climate change (GIH, 2023).

5 One example of the substantial economic damages from failed adaptation is the 2019 wildfires in Canada. These damages encompassed direct impacts as well as indirect consequences like air pollution, disruptions to businesses, and declines in tourism revenue (Newman and Noy, 2023).

1.4 The triple dividend of climate adaptation

Investing in adaptation reduces future costs, and brings economic benefits and socio-economic co-benefits. While in the short-term, investment in adaptation measures may not stimulate economic output and welfare[6], studies suggest that in the longer term this investment can yield significant benefits. Research by the World Bank estimated an adaptation investment dividend of 1:4 (World Bank, 2019), while more recent research indicates that for every US dollar invested in adaptation this decade, an overall economic benefit of USD 12 could be generated (Standard Chartered/KPMG/UNDRR, 2024). The UNEP *Adaptation Gap Report* (2023) notes that studies indicate that USD 16 billion invested in agriculture per year would prevent about 78 million people from starving or suffering from chronic hunger because of climate change impacts. Similarly, it has been estimated that every USD 1 billion invested in adaptation against coastal flooding leads to a USD 14 billion reduction in economic damages. The Global Commission on Adaptation (2019) offers more detailed estimates of these benefits. They state that investing USD 1.8 trillion globally in five key areas from 2020 to 2030 could result in USD 7.1 trillion in total net benefits. Priority investment areas include early warning systems, climate-resilient infrastructure, improved dryland agriculture, mangrove protection, and investments in enhancing water resource resilience. Appropriate adaptation measures can work to reduce vulnerability to natural disasters, thereby reducing economic losses following significant weather events. This can also help reduce insurance payouts, which in turn should decrease insurance premiums, making them more affordable to a larger proportion of the population.

By reducing systemic risks in the economy, adaptation actions can generate three different types of benefit also called "triple dividend", a concept introduced by Surminski *et al* (2016) and further developed by Heubaum *et al* (2022). Related work appears in Allan *et al.,* 2019, report for Global Commission on Adaptation, 2019, and European commission Joint Research Centre PESETA IV study, 2020):

- **Avoided losses and damages are one of the central dividends of adaptation investments.** The materialization of climate risks affects public and private finance both directly and indirectly. Responding to events caused by climate change requires disaster relief or reconstruction of damaged public infrastructure from extreme climate events, relief payments for farmers affected by drought or flooding, etc. By reducing these risks, adaptation can not only decrease these outlays but also the fiscal space needed for contingency planning.
- **Economic and development benefits** are the accrued dividends through investments in adaptations that improve outcomes, including reduced risk of flooding, lower costs of insurance, lower maintenance and repair costs, and increased income (World Resources Institute, 2022), translating into revenue for governments' budgets.
- **Socio-environmental (non-market benefits) effects** also include effects that result in deeper structural changes in the economy, such as the reduction of social inequalities. The socio-environmental effects may occur (and intensify) over time and yet not be immediately visible. Nonetheless, these effects are likely to have a profound impact on public finances.

1.5 Uneven distribution of adaptation challenges across the world

The impacts of climate change and the challenges of adaptation are not evenly distributed globally. Economic damages from extreme weather events disproportionately affect lower-income countries, leading to higher relative economic losses compared to their GDP (Newman and Noy, 2023), especially for the Least Developed Countries (LDCs) of Asia, Africa, the Middle East, and Small Island Developing States (SIDS), which face acute impacts and response challenges due to their greater exposure to physical risk, low adaptive capacity and high vulnerability. As a result, they have a relatively greater need for adaptation finance[7]. Their governments may have more limited financial resources in addition to dealing with competing priorities (e.g. health, education, employment), leaving them with very little fiscal space to finance adaptation projects. In addition, they may be lacking foundational market infrastructures

6 Expenditure on adaptation has some similarity to expenditure on repairs which is subject to the "broken window fallacy" and, due to the opportunity cost of constraint on other investment, does not increase economic welfare.

7 The interplay of hazard, exposure and vulnerability is further developed in section 2.1.

(e.g., efficient capital markets, credit guarantee systems, sound development policies) which form part of the ecosystem necessary to scale sustainable and adaptation finance. Finally, as the cost of insurance increases in areas with high exposure to climate hazards and lower levels of adaptation, policies may become unaffordable for some individuals, and lead to worsening protection gaps. These could disproportionately affect EMDEs and low-income earners in general and could inhibit the access of individuals to financial services, thereby affecting financial inclusion.

The Climate Policy Initiative (Buchner *et al.* 2023) estimates that developing countries will need USD 212 billion per year by 2030 in adaptation finance, but only received USD 63 billion in 2021/2022. The UNEP Adaptation Gap Report (2023) estimates that low-income countries require around USD 22 per capita annually for adaptation finance (3 to 4% of GDP), with an interquartile range[8] (IQ) of USD 9 to USD 36. In lower-middle-income countries, the average per capita adaptation finance needs increase to USD 51 (with an IQ range of USD 22 to USD 109).

Adaptation also has a key role to play in advanced economies. In advanced economies, the physical and social effects of extreme weather events, and the associated loss of life, tend to be significantly lower than in EMDEs (IMF, 2022). However, the financial losses tend to be larger in absolute terms and these financial impacts can cause consequent economic and social harm in advanced economies. Research focused on the United States found that climate change has a long-lasting adverse impact on real output in various states and economic sectors, as well as on labour productivity and employment (Mohaddes *et al.* 2022). Adaptation can build resilience to climate change and climate-driven perils, moderating losses and supporting communities and businesses.

Climate adaptation needs are highly localised. Each country and region face different challenges due to the change in its climate and geography together with its exposure to physical risks. Challenges in climate adaptation at a country or regional level also stem from competing government priorities, and social factors such as lack of community or cultural acceptance (such as the opposition to emissions-based taxation or to the building of sea walls which affect local fishing areas), which hinders the development or implementation of climate adaptation projects. For this reason, adaptation measures must be tailored to local contexts. UNEP's Global Adaptation Network (GAN) highlights that the Global Goal on Adaptation (GGA) shares key similarities across Asia-Pacific, Africa, and Latin America & the Caribbean (LAC). Essential elements include: (i) **inclusivity and participation,** ensuring diverse stakeholders like local communities, youth, women, and indigenous groups are involved to address specific vulnerabilities, (ii) **science-informed metrics**, which stress the need for robust scientific data and improved national monitoring to develop and assess effective adaptation strategies, (iii) **regional cooperation and coordination**, crucial for managing shared climate risks through cross-border collaboration and knowledge exchange, (iv) **adaptation finance**, which must cater to regional financing needs and prioritize funding for the most vulnerable communities and (v) **country-driven and locally-led approaches**, ensuring that adaptation strategies are flexible and aligned with national priorities and existing frameworks.

8 The range from the 25th to the 75th percentile of estimated possible outcomes.

2. Integrating climate adaptation with financial risk management

Insufficient adaptation to climate change can impact the real economy and the financial system (Section 1), while investing in adaptation can yield significant economic benefits.

Given the economic costs of climate change and the risk mitigation role of adaptation, it is essential that the financial system adapts to integrate climate risk and climate adaptation in its risk management practices. Central banks and supervisors can play an active role: through their actions, they can encourage better risk management practices in the financial system.

Insurance plays a key role in protecting the real economy, providing financial resilience against the impact of climate change and encouraging investment in physical resilience. It is, however, only one component of a comprehensive climate risk management framework, and other non-insurance related measures continue to have an important role to play.

2.1 Anchoring risk management actions in the different dimensions of climate risk

Climate risks arise through three interacting risk factors: hazards, exposures and vulnerabilities. The relationship between these three variables is highly non-linear, involving a complicated interaction that is non-stationary and is evolving over time. Acute hazards such as tropical cyclones, wildfires and floods, together with chronic hazards such as increasing average sea surface temperature and sea level rise, can be considered "exogenous". They can be mitigated, primarily through policies to reduce greenhouse gas emissions. An increase in these hazards is already "locked-in" since there is a time delay when it comes to the effects of greenhouse gas emissions. Current hazards are caused by emissions from the past decades and current mitigation activities will not immediately reduce impacts from climate change. Climate hazards interact with the exposure and vulnerability of human and ecological systems. Climate exposure refers to the presence of people, livelihoods, ecosystems and other assets in places that could suffer negative effects from climate change. Climate vulnerability reflects "the propensity or predisposition to be adversely affected" by climate change (IPCC, 2022). Given exposure to a hazard, vulnerability determines the severity of its impact.

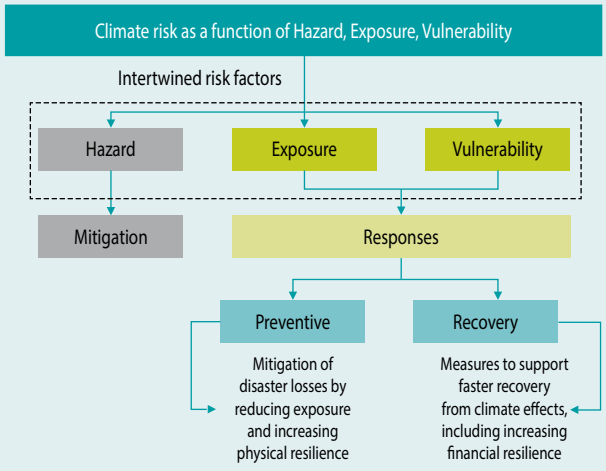
While hazards can be influenced by mitigation measures, exposures and vulnerabilities can be addressed by adaptation measures. Climate adaptation involves reducing exposure and increasing physical resilience. Adaptation includes policy measures, such as zoning and land-use rules that avoid development in higher risk areas, and infrastructure projects such as river levees that aim to reduce climate exposure. Adaptation also includes hardening infrastructure, for example reinforcing roofs and installing high-impact windows that can protect against hurricane damage. These adaptation measures aim to enhance physical resilience, making communities less vulnerable to climate hazards. Measures to reduce exposure and increase physical resilience are both preventative measures that aim to reduce the impact of climate events as much as possible. Across much of the world today communities are exposed to extreme weather events with a built environment that is not adequately resilient to these events. This means that the challenge of climate adaptation involves adapting not only to the current climate conditions, but also to a changing climate, which will further increase this challenge.

There is also a need to better support recovery after climate events occur, including through improving financial resilience and closing insurance protection gaps (Figure 2). Preventive measures will not be able to fully eliminate climate risk. It is therefore also important to have mechanisms in place to help people and institutions recover after climate events occur. These recovery measures include investing in disaster response emergency services capabilities, and community shelters. An important category of recovery measures is the provision of financial support to help communities to rebuild after severe events. This support includes insurance against natural perils and government support or compensation schemes. Just as physical resilience is inadequate in many areas exposed to climate risks, the same is often true of financial

resilience as is evident by the extent of insurance protection gaps around the world. While the term "climate adaptation" is commonly used for efforts to reduce the physical impacts of climate events, steps to improve financial resilience could also be seen as an "adaptation" or adjustment in a broader sense. Developing risk-transfer mechanisms and insurance protection for natural perils, which may require public sector support such as through reinsurance pools, are examples of this type of effort to enhance financial resilience. In addition, insurance has the potential to encourage policy holders to take steps to reduce vulnerability to hazards through so-called impact underwriting for example[9]. Where exposure and vulnerability to natural perils increase, insurance premiums subject to risk-based pricing serve as a signal of this increasing risk. Other financial resilience measures supporting recovery, such as public compensation schemes, may not have the same potential to encourage preventive adaptation measures[10].

Both preventive and recovery measures are interdependent and not mutually exclusive. This interconnection is crucial in understanding the complex dynamics of managing and adapting to climate change risks.

Figure 2 **Responses to climate risk – climate risk is a function of hazard, exposure, and vulnerability**



Adaptation actions and efforts to improve financial resilience to climate events all ultimately reduce the impact of hazards on financial stability and inflation. For this reason, central banks and supervisors can benefit from taking action to encourage better risk management practices in the financial system. Indeed, encouraging more rapid implementation of adaptation measures and efforts to close insurance protection gaps will support their mission of ensuring price and financial stability, through reducing the costs and reaping the benefits described in Sections 1.3 and 1.4.

Preventive investment in risk reduction is the most cost-effective approach to addressing disaster costs as these costs can then be avoided for multiple occurrences of disaster events. As a result, the relative benefits of risk reduction investments are particularly high in communities facing chronic or acute effects of climate change. Often, the most cost-effective risk mitigation actions are to prevent building in the high-risk areas and ensure robust building standards to reduce the impact of disaster events. Relocating existing dwellings and infrastructure may also be necessary, although this is generally an expensive and socially disruptive process. Governments have a critical role to play in climate risk reduction measures. Government agencies (across all levels of government) can focus on establishing appropriate land-use requirements and building codes, provide funding for community-level protection measures such as flood barriers or sea walls, and also provide financial support for risk reduction to households and businesses. Where a project has higher financial risk because it does not meet certain safety standards from an adaptation perspective, or it is identified as higher risk based on a climate risk assessment, supervisors may require lenders to manage such risks appropriately. This may include appropriate pricing of such risks, and ensuring that they remain within the lender's risk appetite. Engaging with clients to better understand and support their adaptation measures would help lenders achieve this.

9 Impact underwriting, a term coined by EIOPA (2023) is the ability of insurers to contribute to climate change adaptation through their underwriting practices in terms of data, risk management and expertise, provides a measure to encourage policy holders to take up climate-related adaptation measures, i.e. to improve their resilience against extreme weather events.

10 For example, regular government bailouts after extreme weather events may weaken the signaling strength of risk-based insurance pricing.

While an important aspect of adaptation to climate change is investment in improving resilience to extreme weather events that can be expected to increase in frequency and/or severity, the adaptation challenge is broader than this. The effects of climate change include chronic changes such as reductions in crop and livestock productivity, increased desertification and drought, deterioration in the availability and quality of water and increased risk of heat stress, including in urban areas with few green spaces. Mitigating the risks of these effects requires a range of infrastructure and technology investments that go beyond resilience to extreme weather events. Conversely, disaster risk reduction includes investment in resilience against events unrelated to climate change such as earthquakes and volcanic eruptions (Coninx *et al.*, 2016). In this sense, climate adaptation and disaster risk reduction are distinct but overlapping investment domains.

2.2 Embedding adaptation into financial risk management

Central banks and supervisors can encourage and support financial institutions in their assessment of the costs and benefits of adaptation. Many central banks have strong analytical capabilities that can support these assessments by providing knowledge and tools, for example by considering the impact of adaptation in the outcomes of their climate scenarios, which can then be applied by financial institutions to perform their own assessments. They play a key role in creating shared resources with their climate risk assessment analysis. For example, floods in the Netherlands have the potential to have a significant impact on the Dutch economy and financial institutions and so over recent years, De Nederlandsche Bank (DNB) has conducted scenario analysis for flood risk. Two recent De Nederlandsche Bank (DNB) studies (2021, 2023) point to a potentially material impact, though in the short run these impacts are likely to be manageable for financial institutions (see Annex for more details).

With financial institutions potentially having significant exposure to climate risk through their investment and lending portfolios, they may be encouraged to embed adaptation objectives and criteria in their transition plans and risk management practices. In order to do this, institutions would need to assess their exposure to climate hazards (through their own operations or through their investment and lending portfolios) and take preventive measures to reduce their vulnerability (e.g., through investments to climate-proof their buildings against acute and chronic physical risks). In areas where preventive measures cannot be taken, or where institutions remain partially vulnerable after implementing these measures, they may also consider recovery measures. Where their mandates allow[11], financial supervisors may consider requiring the inclusion of adaptation considerations in transition plans, which currently tend to focus on mitigation rather than adaptation, as identified by the NGFS (2023c). The NGFS defines financial institution transition plans in a broad sense as an articulation of a financial institution's strategy to tackle risks associated with climate change and the transition to a low-emission and climate-resilient world. This inherently encompasses both actions to adapt to climate change and mitigate it, resulting in the need to manage both transition and physical risks.

Adaptation could also be more systematically considered in investment decisions by financial institutions. As discussed above, while adaptation comes at a cost, it also brings future economic benefits as well as avoided future losses. Adaptation to current climate as well as climate change could therefore be considered in risk-management practices when making investments decisions, just as other factors weighing on profitability and risk exposure are. A limitation of this approach worth noting is that these assessments would typically only cover the duration of the financing. This period may be shorter than the horizon over which climate-related physical risks would materialise, leading to a mismatch in capital allocation as short-term climate risks (including impacts of adaptation to current climate) are likely to be lower than the longer-term risks. In addition, further analysis could be helpful in better understanding the risk implications of climate change associated with individual exposures. This could assist regulators in exploring options for appropriately reflecting climate risk through regulatory and supervisory frameworks, such as supervisory review practices and capital risk weights (for the credit exposures of banks and insurers), where resilience measures demonstrably reduce credit risk within the risk horizon (as set out in the Basel FAQs). Any revisions to risk weights would need to be carefully considered to ensure they do not undermine

11 That said, a wholly prudential mandate would also see supervisors encouraging regulated institutions to take risk management actions which could include adaptation.

the main objective of prudential regulation, i.e. preserving the safety and soundness of the financial system.

Additionally, central banks and supervisors can have a role in supporting the integration of adaptation into sustainable finance taxonomies (where available or under development), both on a regional and a national level. Once established, central banks and supervisors could support the adoption and implementation of these taxonomies by financial institutions in order to improve market transparency. Generally, fragmentation between mitigation and adaptation taxonomies should be avoided, and unified taxonomies should be considered (e.g. Climate Bonds Initiative Resilience Taxonomy, 2024). However, one argument against this concept is that adaptation and resilience issues are highly localised and the economic and social impacts will differ greatly across countries, sectors, and jurisdictions. As a result, many jurisdictions are working on taxonomies that balance localisation and inter-operability. Many existing taxonomies focus on investment in climate change mitigation measures but there is scope to expand these to include investment in adaptation measures.

All of these measures hinge on the availability of relevant climate adaptation and resilience data and disclosures by the recipients of financing, highlighting the importance of better policies on corporate disclosure requirements for climate-related information. Adequate disclosures from financial and non-financial institutions, and an appropriate regulatory framework, can support these risk-management efforts.

National Adaptation Plans (NAPs) are increasingly being developed or implemented in many developing and least developed countries to address their medium- and long-term climate adaptation priorities (Hammil, A., Dekens, J., Daze, A., 2020). Based on the 2023 report on the *Progress in the Formulation and Implementation of NAPS*, 49 countries, including 22 LDCs and 11 Small Island Developing States (SIDS), had developed and submitted their NAPs to the United Nations Climate Change Secretariat as of 11 November 2023. The report showed that climate risk analysis, vulnerability assessments and funding sources are all considered to be key elements to building and implementing their adaptation actions. Progress in the NAPs of countries is considered in their Nationally Determined Contributions (NDCs), indicating the importance of adaptation in meeting climate goals. It is important that policies and other initiatives of central banks and supervisors are shaped consistently with the adaptation strategies and priorities of their respective jurisdictions. For example, central banks in some countries, such as Morocco, have set adaptation targets as part of their NDCs to the Paris Agreement (see Annex for more details).

The interplay between preventive and recovery climate adaptation measures, facilitated by climate-specific insurance mechanisms (discussed further in section 2.2 below), creates a more robust and adaptive framework for managing climate risks. This holistic approach allows for better preparation for future climate challenges while providing a safety net for when preventive measures are insufficient or impractical in the face of unavoidable climate impacts.

2.3 Affordable insurance as a recovery tool to mitigate macroeconomic losses

Natural hazards resulted in insured losses of USD 108 billion in 2023 (Swiss Re Institute, 2024)[12]. Insured losses surpassed the USD 100 billion mark for a fourth consecutive year in 2023. Annual insured losses have been growing by 5-7% on average for the last three decades, and this trend is anticipated to continue over the long term. Total economic losses in 2023 reached USD 280 billion, meaning 60% of global exposures were uninsured: a significant protection gap.

While insurance is not a physical resilience measure, it enhances financial resilience. In the face of risks associated with a changing climate, financial resilience is valuable as it can help individuals, businesses and communities to better and more quickly recover when climate risk events manifest. Insurance must also be supported by investments in physical resilience to remain effective: physical and financial resilience are closely linked and pursuing the latter on its own would be futile as growing physical risks will undermine the affordability of insurance,

12 These figures should be considered with caution in the context of this Conceptual Note which focuses on the effects of climate change, as other non-climate related natural disasters (e.g. earthquakes) may be included in the figures.

eroding financial resilience. Thus, while addressing physical resilience should be a priority, financial resilience, including adequate insurance, also has a role to play in adapting to climate change.

Against this backdrop, central banks and supervisors should consider the importance of insurance affordability and availability for the wider financial system. Where central banks and supervisors help to encourage investment in physical resilience, one of the benefits of increased investment in physical resilience is that insurance is likely to become more affordable, reflecting reduced risk exposure to extreme weather events. Given the benefits to financial stability, this is an area of interest to central banks and supervisors who have a particularly important role to play, which is discussed further below. Central bank and supervisors can act in collaboration with different stakeholders to encourage this: for instance, the Bank of Greece works closely with government ministries and the Greek Insurance Entities Association to exchange information and develop strategies to reduce the insurance protection gap (see Annex). In the case of the Netherlands, following the harmful economic impacts of the 2021 flood events, and the lack of insurance coverage in areas prone to severe flood events, the DNB provided recommendations for both government and the insurance sector (See Annex).

The interaction between insurance affordability/availability and economic activity and financial stability could also be considered by central banks and supervisors, within the framework of their mandates. Available and affordable insurance can have positive benefits on credit underwriting and the lack of available and affordable insurance can have the opposite effect. Kahn, Panjwani and Santos (2024) have shown a positive effect of insurance availability on agricultural lending, as banks increased lending to the agricultural sector in counties with higher insurance coverage after 1980, even when affected by adverse weather shocks. Blickle and Santos (2022) showed the impact of increasing insurance premiums – in the case of mandatory flood insurance – on borrower credit worthiness. They showed that lending to low-income and low-credit score borrowers declined due to the requirement to pay flood insurance premiums. It should be noted that addressing the issue of insurance affordability (including through subsidies) generally falls under the responsibility of other policymakers, not financial supervisors. Given their prudential mandates, insurance supervisors require insurers to price insurance according to the underlying risk and hold sufficient reserves. If the underwriting indicates a high level of risk, higher prices are appropriate from a prudential perspective. Considering this point, it is also important for central banks and supervisors to balance their prudential obligations with their support to initiatives aimed at improving affordability and availability of insurance. However, central banks and supervisors should consider the financial system as a whole, to avoid risk transfers to other parts of the system, such as the insurance sector.

Higher levels of insurance penetration positively impact governmental budgets and can mitigate contractions in economic activity after extreme weather events, therefore fostering a more favourable environment for price and financial stability. As highlighted in ECB/EIOPA (2023), insurance payouts reduce uncertainty and support aggregate demand and investment for reconstruction, enabling economies to recover faster and limiting the period of lower economic output. In fact, economies may recover faster from catastrophes when a larger share of damages is covered by private insurance (Von Peter *et al.,* 2024). The availability of insurance for natural perils also dampens the fiscal consequences of extreme weather events, as governments will bear less of the burden when these events strike (Melecky and Raddatz, 2011).

The cost of climate-related insurance can serve as a powerful signalling mechanism for implementing preventive adaptation measures, through the application of impact underwriting and the use of risk-based pricing. Beyond providing financial protection, insurance can play an important role in identifying assets at risk and encouraging risk reduction and adaptation (OECD, 2023). Risk-based premiums can serve as a risk signal to households and corporates and may lead to incentives for adaptation and risk reduction measures. Impact underwriting, coined by EIOPA (2023), is the ability of insurers to contribute to climate adaptation through their underwriting practices, data, risk management and expertise. It provides a measure to encourage insurance policy holders to improve their resilience against extreme weather events. As insurance premiums rise to reflect increasing climate risks, individuals,

businesses, and governments are likely to be encouraged to invest in climate-resilient infrastructure and practices. This relationship creates a feedback loop: higher insurance costs for climate-related damages encourage more robust adaptation measures, reducing the exposure and/or vulnerability to climate risks and placing downward pressure on insurance premiums over the medium term. For example, in coastal areas facing sea-level rise, increasing flood insurance costs may prompt communities to invest in sea walls, elevated structures, or even managed retreat, thereby reducing their vulnerability to future flooding events. These adaptation measures eventually feed back into risk pricing and benefits both the insurer and the insured. However, it should be noted that there can be a tension between risk management by insurers and the impact on lenders. Insurers mitigate risk by withdrawing or increasing premiums, which increases the risk for banks as their assets held through households' mortgages may no longer be insured in the event of a severe risk event.

Initiatives are being taken to address the insurance protection gap, but further work is required. Risk sharing is a fundamental element of insurance. Particularly, low frequency, high impact risks such as extreme weather events require some form of risk sharing, as the individual insurer may not be able to bear the risk on its own. Reinsurance reduces capital requirements for the primary insurer and allows reinsurers to participate in further diversification. However, the financial capacity and technical capability of primary insurers and reinsurers may not be sufficient to design insurance and reinsurance products that cover the losses of extreme weather events occurring with higher frequency and intensity. Further layers of risk sharing may be needed. Public-private schemes such as (re)insurance pools can also assist in addressing these protection gaps.

ECB/EIOPA (2023) propose the *ladder approach*, which builds on the interaction of primary insurers and reinsurers, alternative risk transfer via the capital market, public-private partnerships and a potential supranational element dealing with risks that cannot be borne at the national level[13] (European Stability Mechanism, 2023).

As emphasized by the IAIS (2023), addressing insurance protection gaps is a broad challenge that requires a coordinated response from a range of parties including governments, the insurance industry, and consumers. Insurance supervisors also have a crucial role to play, in particular in the five areas described by IAIS:

1. assessing insurance protection gaps
2. improving consumer financial literacy and risk awareness
3. incentivising risk prevention and reduction of insured losses
4. creating an enabling regulatory and supervisory environment to support availability of insurance and uptake of coverage, and
5. advising government and industry, including on the design and implementation of public-private partnerships (PPPs) or insurance schemes.

In the context of climate adaptation, intervention via climate insurance could be relevant in addressing gaps in self-insurance, for e.g. in the following scenarios:

- Managing the impacts of extreme weather events (e.g., hurricanes, wildfires) that are becoming more frequent and severe due to climate change, which individuals or businesses cannot reasonably self-insure against.
- Situations where the cost of climate-proofing assets would be prohibitively expensive, potentially leading to underinvestment in critical adaptation areas.
- Climate-vulnerable assets with positive externalities, such as coastal ecosystems or agricultural lands that provide broader environmental and food security benefits.

For instance, interventions in the form of parametric insurance for farmers in drought-prone regions ensures quick payouts based on predetermined climate indicators, allowing for rapid recovery and maintaining food production capacity.

It is therefore important for central banks and supervisors to consider the implications of insurance affordability and availability challenges on the wider financial system. Insurance supervisors in particular can play a role in addressing the protection gap. However, to do so they need to be involved in pilot schemes and discussions on climate-related hazards management with government officials in their respective countries.

13 On the potential supranational element, proposals have been made to describe what could be the role and design of a European backstop facility for natural catastrophes.

Pilot schemes are particularly relevant for SMEs, for whom the adaptation market is often insufficient, and it makes it more difficult for them to identify and access adaptation solutions. They can also encourage industry action and stimulate consumer demand to strengthen resilience against climate risks. Furthermore, supervisors are also in a good position to act as a bridge and communication catalyst between policymakers, the insurance industry and consumers (A2ii, MiN, IAIS, InsuResilience Global Partnership, 2020).

3. Scaling up climate adaptation financing

To reduce the costs of climate change and reap the benefits of adaptation, mobilisation of adaptation financing is necessary. The NGFS and its members can contribute to this effort, as they have already done (NGFS, 2023b). Addressing the current adaptation finance gap and realizing the economic benefits of adaptation investments will require coordinated action from governments, international organizations, and the private sector. As climate change impacts intensify, bridging this gap becomes not only an environmental imperative but also an economic necessity.

To support the price and financial stability goals of central banks' and supervisors' mandates, scaling up the financing of adaptation will be essential. Conversely, achieving price and financial stability is extremely important for adaptation as this reduces the cost of funding and ensures smooth flow of funds towards adaptation. Current financing for adaptation is very limited, which may be attributed to several barriers including a lack of awareness, the high complexity, and uncertainty over the needs for adaptation and resilience.

However, it should be acknowledged that central banks and supervisors are not the only stakeholders in this endeavour. Many interventions described in this section will need to come from other authorities and policymakers.

3.1 The adaptation finance gap

The current level of climate adaptation finance is insufficient and continues to fall behind funding for climate change mitigation. Authorities such as central banks and supervisors can play a role in closing this finance gap. According to Buchner *et al.* (2023), while adaptation finance increased by 28% in 2021/2022 to USD 63 billion (compared to USD 49 billion in 2019/2020), over the same period mitigation finance almost doubled. One estimate suggests that less than 10% of all climate finance worldwide is allocated for adaptation (Standard Chartered/KPMG/UNDRR, 2024), while the other sources estimate that globally, around 4% of reported climate finance is for adaptation purposes, with around 98% of this financing originating from public sources (Buchner, 2023: cited in World Bank, 2024). The *Adaptation Gap Report 2023* from the United Nations Environment Programme (UNEP) paints a slightly less negative picture for developing countries, where total climate finance is much smaller than in advanced economies, but the share of adaptation in total climate-specific finance is greater compared to advanced nations. For the 2017-2021 period, the share of adaptation was the highest in low-income countries (at 55%), followed by lower-middle-income and upper-middle-income countries (with 38% and 24%, respectively). LDCs and SIDS also received higher commitments for adaptation (51 and 52%) than for mitigation (39 and 30%)[14]. Buchner *et al.* (2023) has a different estimate, and reports that in EMDEs (excluding China), only 16% of climate financing goes to adaptation, and nearly all that financing (98%) comes from public sources, with a limited role of the banking sector (60% of banks allocate 5% or less of their lending portfolio to it). This variance in estimates highlights the difficulty of accurately assessing adaptation financing, but the need for increased financing is uncontested.

The gap in adaptation finance is significant, especially in developing countries. The World Bank notes that channelling more finance for adaptation and resilience investments in EMDEs is challenging, as it requires high upfront costs to reap benefits in the long term. The OECD (2024) points out that the commitment of developed countries to mobilize USD 100 billion per year for climate action in developing countries has been achieved for the first time in 2022, but this collective goal needs to be sustained through to 2025. The annual climate adaptation financing gap in developing countries is estimated to range between USD 194 billion and USD 366 billion, which is around 10-18 times more than current financing flows (Standard Chartered/KPMG/UNDRR, 2024). This gap is projected to grow to USD 315-565 billion by 2050. The UNEP *Adaptation Gap Report* suggests that adaptation costs in developing countries could reach USD 160-340 billion annually by 2030 and USD 315-565 billion by 2050 (UNEP, 2022).

14 The 'climate-specific finance' figure in the UNEP Adaptation Gap Report only considers international public climate finance, which explains the higher figures when compared to the World Bank report which takes into account private climate finance contributions.

These figures are substantially higher than current international adaptation finance flows, which amounted to USD 29 billion in 2020. The Climate Policy Initiative (Buchner *et al.*, 2023) provides similar estimates, indicating that developing countries alone will need USD 212 billion per year by 2030 and USD 239 billion per year between 2031 and 2050 in adaptation finance, but only received USD 63 billion in 2021/2022, pointing to a significant gap.

Several factors can explain the persistence of financing gaps, including data and knowledge gaps, the bespoke nature and complexity of financing instrument, or issues linked to the broader enabling environment. Challenges hampering the development of blended finance, as described by the NGFS (2023b) also apply to adaptation finance. First, data gaps on climate physical risks, fragmented disclosure standards and the lack of robust and interoperable taxonomies can hamper efficient pricing of climate risks and opportunities by investors. Knowledge gaps regarding the financial engineering of adaptation projects can be another obstacle. For instance, SMEs looking to make their adaptation projects financially viable may lack the technical skills to do so. They may need technical assistance or support on how to structure their adaptation projects to become commercially viable. Second, adaptation finance transactions can be complex and difficult to replicate in other areas or expand at a larger scale. Third, central banks and supervisors – as well as policymakers beyond the financial system – could explore the need to enhance policy, supervisory and regulatory frameworks to facilitate adaptation finance, for example on environmental disclosures. Fourth, EMDEs can face specific issues, linked for instance to the lack of development of domestic financial systems and the lack of viable climate projects. A common challenge is a lack of or underdeveloped foundational market infrastructures (e.g. efficient capital markets, credit guarantee systems, sound development policies) which form part of the ecosystem necessary to scale sustainable and adaptation finance. Finally, it can be difficult to determine the right level of adaptation and decisions must be made on whether to aim for a complete elimination of economic costs, or if the goal should be to only reduce risk to an acceptable level of tolerance. If the latter option is chosen, a decision must then be made as to the target tolerance level.

A substantial increase in the scale and speed of adaptation finance is urgently needed (Global Commission on Adaptation, 2019). The OECD (2023) stresses the necessity for international providers to significantly boost their efforts in areas such as adaptation finance and the mobilization of private finance to address the adaptation finance gap. The World Bank has been monitoring contributions to climate adaptation finance, showing an upward trend in adaptation finance in recent years. However, the analysis indicates that current adaptation efforts are still insufficient and private sector engagement needs to be scaled up significantly (World Bank, 2023). This is in line with the IMF's position on the importance of increasing private finance for climate action, emphasizing the need for frameworks that can facilitate the scaling up of climate finance in emerging markets and developing economies.

Adaptation and resilience finance tools and frameworks need to be tailored to regional and national circumstances and capacities. There is a need to tailor tools and approaches for financing to cater for regional variabilities, considering differences between regions in terms of vulnerabilities to natural hazards and economic outlook. Moreover, countries face varying degrees of capacity challenges that affects their ability to access, attract and absorb adaptation and resilience finance. See Annex for case studies of adaptation from a national perspective.

3.2 A role for both the private and public sectors in adaptation financing

The required scale and scope of adaptation efforts and their financing varies with the type of asset and its associated economic activity. It is important to distinguish private from public assets and their respective economic characteristics to determine possible financing channels for adaptation. In the private sector, autonomous adaptation actions can occur through the incremental economic actions and choices of economic actors, if financial system norms, rules, incentives and policies are appropriately enabling. Projects with clear revenue streams (e.g., resilient energy infrastructure) may attract more private investment. However, some climate adaptation measures for private sector assets are not commercially viable and might require public sector support, both from a funding and a technical capability perspective. For example, a coastally located business could not typically justify financially the investment in coastal defences against storm surge. Conversely, many adaptation projects carry

significant societal benefits beyond the private returns. These positive externalities, especially for public sector assets that are not exclusive, may justify public support. Also, high-risk areas or novel technologies may require public sector risk-sharing mechanisms. For both public and private assets, preventive adaptation finance needs to be complemented by measures to improve financial resilience, including those that provide economic incentives for investment (e.g. price signals though insurance costs). The potential for different sources of capital in a blended finance ecosystem, and a sequencing approach to adaptation, are set out further in Box 1.

The global challenge of climate adaptation requires a concerted effort from both public and private financial system stakeholders. While public finance has traditionally played a crucial role in protecting both public and private assets, there is an increasing need to stimulate private sector finance, with financial supervisors and central banks having a supporting role in encouraging capital allocation to both private and public assets.

Financial supervisors and central banks are well positioned to support an enabling environment that encourages the private financial sector to scale up adaptation finance. Depending on the breadth of their mandates, they may foster an enabling environment through collaboration, capacity building or the conduct of economic and financial analyses. Central banks and supervisors can contribute to creating an enabling environment by engaging with stakeholders in the adaptation finance ecosystem, by contributing to the development of foundational market infrastructures, or by providing capacity building initiatives that can help lift barriers to adaptation financing. Central banks and supervisors can also contribute to closing knowledge gaps, by working on the measurement of economic and financial risks linked to the lack of adaptation measures. Furthermore, supervisors could support disclosure requirements and facilitate data availability on climate-related transition and physical risks, enabling more accurate pricing of climate-related financial products. These measures can help reward long-term benefits from sustainability and create a more efficient allocation of capital towards adaptation efforts. Also, they may (1) support regulatory measures that improve transparency and risk management, such as mandatory climate risk assessments for large-scale project finance, and the consideration of adaptation in investment decisions and (2) explore regulatory measures that support demand-side financing initiatives such as "green loans/mortgages" for climate-resilient projects and housing, and explore differentiated regulatory treatment for adaptation and climate-resilient infrastructure projects, particularly for vulnerable communities.

In addition, depending on their mandates and provided operational requirements are in place, central banks could play a supportive role in directing capital towards adaptation efforts through the banking sector. Measures to achieve this may include incorporating climate resilience criteria into their own investment portfolios to set a precedent for the broader capital market.

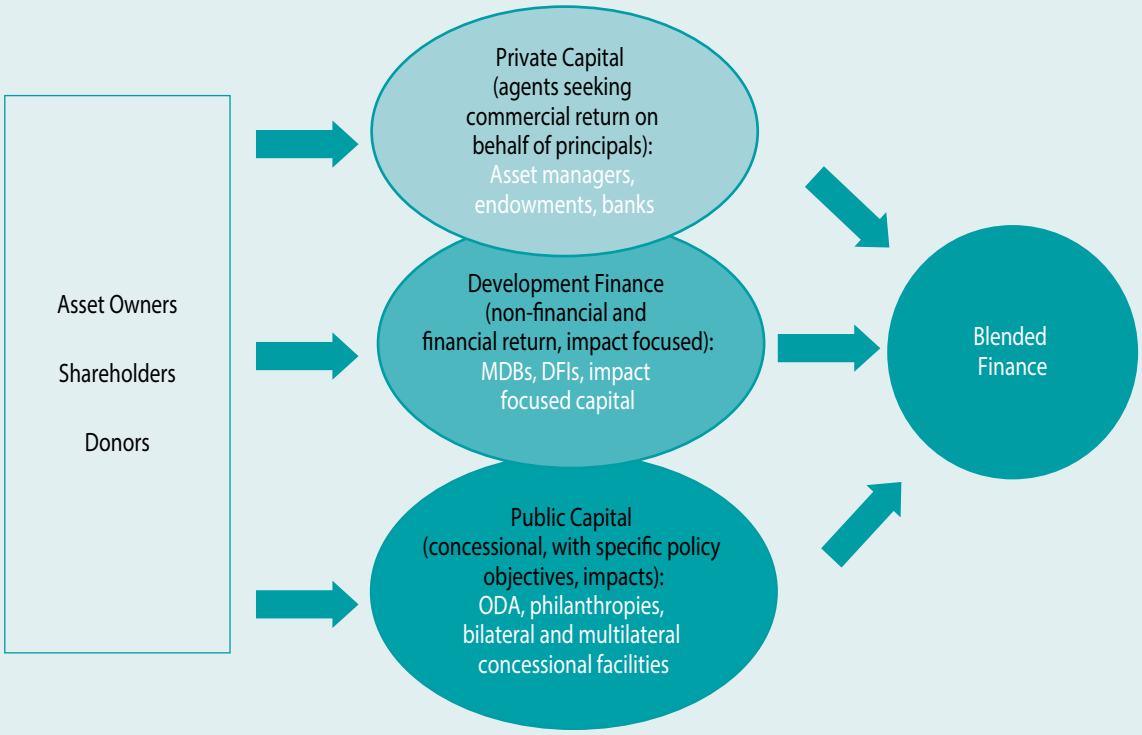
Box 1

Blended finance as a tool for bridging public and private interests in adaptation

Blended finance remains a powerful tool for bridging public and private interests in adaptation finance. The NGFS defines blended finance as "the strategic use of a limited amount of concessional resources to mobilize financing from public and private financial institutions to achieve climate impacts". As shown in Figure 3, designing and implementing blended finance requires partnership across a very diverse set of institutional players such as public (official development assistance, donors, philanthropies, various concessional facilities), private (asset managers, institutional investors, banks, endowments, etc.) and development financial institutions.

.../...

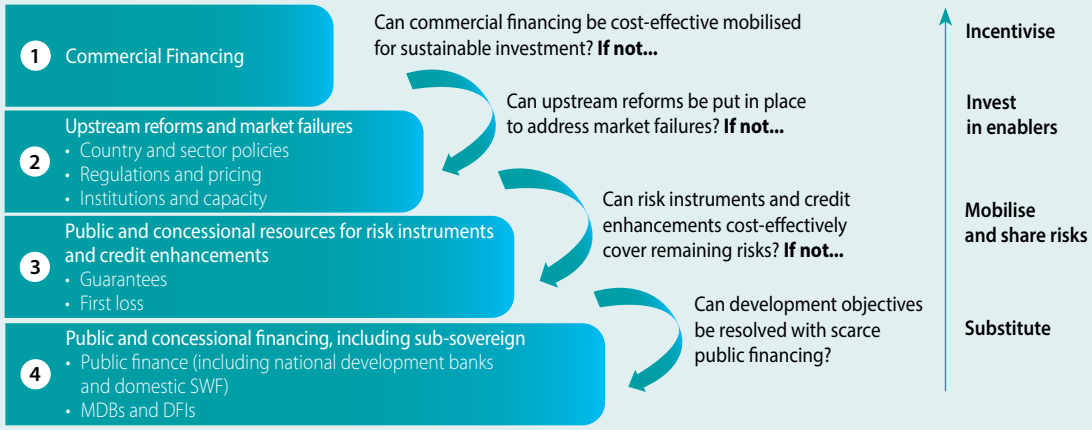
Figure 3 **Blended Finance Ecosystems**



Source: NGFS (2023b). Blended finance initiatives and platforms, include Convergence and G20 initiative on Blended Finance. Information intermediaries include Credit Rating Agencies, and ESG data and product providers. Concerning ethical standards see UN, ICMA, and OECD.

In this context, the World Bank's Cascade framework (Figure 4) provides guidance on a sequenced approach to engaging the private sector. This framework first seeks to mobilize commercial finance, enabled by upstream reforms where necessary to address market failures and barriers to private sector investment at the country and sector level. Where risks remain high, the priority will be to apply guarantees and risk-sharing instruments. Only where market solutions are not possible through sector reform and risk mitigation would official/public resources be used (World Bank, 2017). Concrete applications of the framework should focus on: (1) de-risking adaptation investments through first-loss guarantees or other risk-sharing mechanisms provided by public entities, (2) catalysing private investment in adaptation by demonstrating the viability and profitability of resilience-focused projects and (3) leveraging public funds to create markets for adaptation technologies and services, paving the way for increased private sector participation.

Figure 4 **World Bank's Cascade framework**



Source: OECD, Based on (World Bank Group, 2018[22]), Approach Paper "Creating Markets for Sustainable Growth and Development" 2018, https://ieg.worldbankgroup.org/sites/default/files/Data/reports/ap-creating-markets.pdf.

Public-private sector collaboration is critical to ensure the scaling up of adaptation finance, particularly in developing countries. The UN Pact for the Future (UN, 2024), adopted by the UNGA at the Summit of the Future in September 2024, highlights finance as a crucial enabler of adaptation finance, alongside capacity-building and technology transfer (Art. 9). It specifically acknowledges that increased private sector involvement necessitates an enabling domestic and international regulatory and investment environment (Art. 4). While the Pact does provide specific guidelines for financial regulators and supervisors, its emphasis on enabling environments suggests several potential areas of focus:

- developing clear taxonomies and standards for adaptation finance to improve market clarity and investor confidence;
- implementing disclosure requirements for climate-related financial risks, including physical and transition risks relevant to adaptation;
- integrating climate considerations into prudential regulation and supervision to ensure financial stability in the face of climate change;
- facilitating innovative financial instruments and structures that can channel private capital into adaptation projects;
- encouraging capacity building within financial institutions to better assess and manage climate-related risks and opportunities;
- promoting international cooperation and harmonization of regulatory approaches to create a level playing field for adaptation finance.

These actions by financial regulators and supervisors can help create the enabling environment called for in the UN Pact, potentially catalysing greater private sector involvement in adaptation finance, especially in developing countries where the need is most acute.

4. Key areas of interest for Supervisors and Central Banks

Across the issues explored in this note, it is evident that there are various opportunities for further work on climate adaptation, with direct or indirect roles for central banks and supervisors. This section sets out four potential areas of interest for central banks and supervisors, which could serve as a guide for future NGFS work. The areas of interest outlined in this section acknowledge the diversity of priorities for central banks and supervisors across advanced economies and emerging markets. Where applicable, these areas of interest are tailored to address both contexts, recognizing different levels of financial and policy infrastructure available in each.

Area #1: Role of metrics and tools for better measurement and disclosure of adaptation

To account for the impacts of adaptation measures (or the lack thereof) and better understand their potential impacts on the economy and the financial system, central banks and supervisors could explore metrics and tools that incorporate and measure the impact of adaptation. This could include for instance the definition and adoption of metrics for assessing the resilience benefits of adaptation projects or the financial costs of a failure to adapt. They could also explore how scenarios can account for ongoing or future adaptation measures or projects, to complement static indicators with forward-looking view. To ensure comparability and consistency of metrics or scenarios across countries, which are important for risk management and public disclosures, central banks and supervisors could champion a definition of what qualifies as adaptation investment (e.g. on the basis of the IPCC definitions of adaptation and resilience used in this report) or could support the development of a common taxonomy (where feasible in their jurisdiction) of adaptation projects. Central banks and supervisors need to deepen their understanding of the economic and financial impacts together with the costs of lack of adaptation. Continuing the work on data and metrics (including existing measures used by standard-setting bodies, NGOs and other sources) is a prerequisite to deepen the understanding of adaptation impacts. Central banks and supervisors are already making use of climate scenario analysis, and integration of adaptation measures in scenarios have the potential to shed further light on the cost benefit trade-offs of adaptation measures. Central banks and supervisors are well-placed to promote awareness on the potential of adaptation interventions as risk mitigation mechanisms for financial institutions.

Area #2: Exploring the need to enhance policy, supervisory and regulatory frameworks

Central banks and supervisors could explore options to better reflect adaptation-related issues in existing regulatory or supervisory frameworks. This topic spans a few main areas and will vary depending on the different mandates of the central banks and supervisory agencies. The three main areas discussed are: (i) integrating adaptation considerations into risk management, (ii) proposing supervisory or regulatory framework enhancements that recognise adaptation, and (iii) addressing the insurance protection gaps. Supervisors could assess whether climate risk management practices properly account for the resilience benefits of adaptation policies (or the costs of not having adaptation policies), encourage financial institutions to account for adaptation in their transition plans (where this is within the mandate of regulators), or promote the integration of physical risks and adaptive capacity assessment into credit risk assessments for banks and premium/reserve adequacy for insurers. As noted above, they could also refine scenario analyses by including adaptation policies in the design of these scenarios (e.g. by taking into account the positive impacts of adaptation on the outputs of scenarios). In addition, further analysis could be helpful in better understanding the risk implications of climate change associated with individual exposures. In turn, regulators could explore options for appropriately reflecting climate risk through regulatory and supervisory frameworks, such as supervisory review practices and capital risk weights (for the credit exposures of banks and insurers), where resilience measures demonstrably reduce credit risk within the risk horizon (as set out in the Basel FAQs). Any revisions to risk weights would need to be carefully considered to ensure they do not undermine the main

objective of prudential regulation, i.e. preserving the safety and soundness of the financial system.

Central banks and supervisors could further examine the importance of insurance affordability and availability for the wider financial system and contribute to efforts to reduce protection gaps. Insurers cannot solve the problem of protection gaps on their own, nor can financial authorities. Therefore, it is important to address protection gaps by coordinating with multiple stakeholders across both the public and private sectors. Central banks and supervisors, particularly insurance supervisors, can make a significant contribution to this challenge, providing data, analytical capabilities and industry expertise to bear. A recently released IAIS report on this topic (2023) has identified five areas for further work by insurance supervisors in addressing the protection gaps and many of these are closely aligned to the key areas of interest suggested in this note. Given the importance of insurance in financial stability and in supporting bank lending (e.g. by providing insurance cover for loan collateral), this work is of relevance not only to insurance supervisors but to other NGFS members more broadly.

Finally, central banks and supervisors can work on improving consumer financial literacy and risk awareness as well as ensuring that the benefits of risk prevention measures are understood. Ensuring robust disclosure of information related to adaptation, such as physical risk metrics, and potential resilience provided through adaptation policies, could also support financial institutions' risk management and supervisors' assessments of climate risk management practices. The NGFS can play a key role in compiling relevant examples of adaptation and risk mitigation interventions that supervisors could use to guide financial institutions.

Area #3: Fostering an enabling environment for adaptation finance

Central banks and supervisors may engage with a broad set of public and private stakeholders to help foster an enabling environment. There are many international collaboration networks and agencies driving action on adaptation through awareness raising, resource sharing and facilitating adaptation financing. Central banks and supervisors can engage with organisations, such as environment agencies in charge of national adaptation plans or construction authorities responsible for infrastructure resilience standards, to share data and insights. Contributing to closing knowledge gaps and capacity building across all stakeholders through training and development of knowledge-sharing platforms could assist with the dissemination of information on climate-related risks and opportunities and improve decision-making. Collaborating on the definition of clear and robust common standards, disclosures and taxonomies for adaptation finance to improve market clarity and investor confidence could also play a role. It could facilitate the use, for instance, of innovative financial instruments tailored for adaptation investments that can channel private capital into adaptation projects (including developing green/sustainability bonds that include adaptation-focused criteria), or of Fintech initiatives that stimulate the development of new adaptation technologies and business models addressing adaptation finance challenges. Central banks and supervisors can also contribute to the development of foundational market infrastructures (e.g. efficient capital markets, credit guarantee systems, sound development policies) which form part of the ecosystem necessary to scale sustainable and adaptation finance. Engagement with a broad set of stakeholders involved in the ecosystem of adaptation finance, such as public development institutions, multilateral development banks, city councils or private organisations involved into public-private-partnership, could help foster positive impacts on adaptation projects. Central banks can further contribute to adaptation research by collaborating with academic institutions to improve understanding of climate impacts on economic stability and inflation dynamics, especially in emerging markets, where adaptation research is often underfunded.

Area #4: International collaboration, with actions focused on local considerations

Risk mitigation, enhancing financial resilience and scaling up adaptation finance hinge on public policies defined at the national, regional or local level, and are embedded in a local regulatory and climate risk context. However, they can benefit significantly from the involvement of a pool of international organisations.

It is important for national actors (across the financial system, planning bodies and local agencies) to leverage international collaboration networks and agencies driving awareness raising and sharing expertise. However, to maximise the impact of adaptation initiatives, it is equally important for them to focus on actions and activities that respond to the specific context of local, regional and national communities. Similarly, risk mitigation and adaptation finance initiatives that central banks or supervisors may be involved with need to follow harmonized approaches (e.g. through engagement with international forums), while remaining consistent with adaptation strategies implemented by governmental agencies. Close collaboration with local, national and international stakeholders is key.

The NGFS intends to pursue these topics further in the coming years.

Annex – Delivering Climate Adaptation: National Perspectives

In view of the rising severity and frequency of physical risk events, several NGFS members have started identifying adaptation needs or implementing adaptation policies. Central banks and supervisors are supporting these efforts within the limits of their mandates. The examples described in these case studies show that there are many ways in which central banks and supervisors can act to contribute to the climate adaptation challenge. National adaptation strategies define the national ambition and are a means to increase resilience to climate change. Some countries like Morocco have set explicit adaptation targets as part of their Nationally determined contributions (NDCs) to the Paris Agreement. Central banks can draw on the objectives of national strategies, or support some of them by focusing on issues relevant to them, such as limiting risks from rising protection gaps. For instance, the Bank of Greece participates in developing Greece's national strategy for addressing the private insurance protection gap for natural catastrophes and monitors the insurance sector's adaptation progress under the LIFE-IP adaptation project. Central banks can also, in turn, provide recommendations on ways to address risks linked to the lack of adaptation. For instance, given the harmful economic impacts of the lack of insurance coverage in areas prone to severe flood events, the De Nederlandsche Bank (2022) provided recommendations for both government and the insurance sector in *Insurers in a changing world* (2022). Central banks and supervisors also act on the lack of adaptation by issuing directives or regulations to make sure the financial system manages climate-related risks. Bank of Ghana's 2024 directive on climate-related financial risks mandates banks and financial institutions to assess how climate change could affect their business models and strategies, ensuring the sector's resilience in the face of climate threats.

Each of these examples shows that adaptation challenges are location-specific. Local specificities imply that different regions can be exposed to different types of physical risks (floods, typhoons, extreme heat waves, sea level rise, etc.), and that policies depend on the local regulatory or enabling environment. These case studies can provide an inspiration for authorities wanting to tackle adaptation-related challenges, and may help define a starting point for their own efforts to contribute to climate adaptation.

a. Ghana

Ghana's evolving economy, though now driven by the services sector, remains deeply vulnerable to climate change, especially in agriculture, water resources, energy, and infrastructure. Ghana has adopted various international climate frameworks, including the Paris Agreement, and integrated these commitments into its NDCs, with a focus on both mitigation and adaptation efforts.

A key adaptation priority for Ghana is enhancing private sector engagement in climate resilience, notably through financial system initiatives. The Bank of Ghana's 2024 directive on climate-related financial risks marks a pivotal step in embedding climate risk into financial regulation. This directive mandates banks and financial institutions to assess how climate change could affect their business models and strategies, ensuring the sector's resilience in the face of climate threats.

Key lessons for central banks and supervisors from Ghana's experience include:

- **Integrating Climate Risk into Financial Supervision:** Financial regulators must incorporate climate risk assessments within the regulatory framework, ensuring that institutions identify and mitigate these risks. This will require clear guidelines, ongoing training, and tools to understand the financial impacts of climate risks.
- **Supporting Green Financing:** Initiatives like the Sustainable Use of Natural Resources and Energy Finance (SUNREF) program and green credit lines, which fund renewable energy and energy efficiency projects, show the importance of facilitating access to sustainable finance. Central banks can play a role by collaborating with international development partners to incentivize green investments, which are critical to building climate adaptation and resilience in the economy.

By fostering such financial system responses, regulators can ensure that adaptation to climate change is prioritized within the economic framework.

b. Greece

The Bank of Greece (BoG) was one of the first central banks to actively participate in efforts to address the issues of climate change, including adaptation. It has been doing so mainly through conducting of research, participating in policymaking and disseminating the results of these studies to the wider public to raise public awareness.

The BoG has progressed its own work and has participated in numerous national initiatives that serve as a model for how central banks can support adaptation efforts. These may in turn contribute to price and financial stability, as well as long-term economic resilience. Some of the key achievements are:

- Establishment of the interdisciplinary Climate Change Impacts Study Committee (CCISC): established in 2009, this committee leads research on the economic, social, and environmental impacts of climate change in Greece.
- Publication of the CCISC flagship study 'The environmental, economic and social impacts of climate change in Greece' (2011).
- Contribution to drafting the National Strategy for Adaptation to Climate Change (2015), building on the experience of the CCISC regarding the economic and other impacts of climate change, to help shape the country's response to climate risks.
- Endorsement and support of the Principles for Responsible Banking developed by the United Nations Environment Programme – Finance Initiative (UNEP-FI, 2018).
- Participation in the LIFE-IP AdaptivGreece (2019): BoG is a core partner in this 8-year project, which is the most important project for adaptation to climate change in Greece.

Some of the most important findings of the research study mentioned above is that adaptation measures in Greece could reduce climate-related costs by 30% while promoting sustainable growth. The BoG sees adaptation measures as essential for mitigating the impacts of climate change on the economy, financial stability, and risk management.

Addressing the insurance protection gap: BoG has taken several steps to tackle the significant insurance protection gap for natural disasters. It engages with the insurance sector on sustainability issues, participates in developing Greece's national strategy for addressing the private insurance protection gap for natural catastrophes and monitors the insurance sector's adaptation progress under the LIFE-IP project.

A collaborative approach: The BoG works closely with government ministries and the Greek Insurance Entities Association to exchange information and develop strategies to reduce the insurance protection gap. This collaboration supports a more climate-resilient financial system and enhances insurance's role in adaptation efforts.

The example of the BoG demonstrates how central banks can support climate adaptation while ensuring financial system resilience by driving research, shaping national adaptation policies, sharing data and information, and addressing insurance vulnerabilities.

c. Ireland

Climate change is causing significant impacts on various aspects of Ireland's environment, society, and economy, affecting ecosystems, water resources, agriculture, public health, and coastal areas. The severity of these impacts underscores the urgent need for comprehensive adaptation strategies.

Adaptation to climate change involves developing proactive measures to prepare for and respond to its effects. This includes actions aimed at reducing vulnerabilities, enhancing resilience, and protecting communities and economies. Ireland's adaptation framework outlines strategies for stakeholders to implement these measures effectively. Key adaptation actions include modifying infrastructure, land use practices, and resource management, as well as setting up early warning systems. By planning and preparing for climate impacts, Ireland can better address challenges like shifting weather patterns and rising sea levels.

However, addressing adaptation finance is crucial due to the increasing need for investment in response to climate change. Despite progress in funding mechanisms and adaptation strategies, there are still challenges in understanding and managing adaptation costs.

Ireland's National Adaptation Framework has made strides but requires updates to incorporate new developments. Research on climate impacts and adaptation is ongoing, with significant progress in areas like climate modelling and risk assessment. For effective adaptation, it is essential to integrate climate considerations into decision-making and public investment, ensuring adequate funding and prioritizing adaptation needs for long-term resilience (Government of Ireland, 2024).

d. Morocco

Morocco is one of the countries on the African continent most exposed to climate change. It is already experiencing growing risks from drought and flood with significant economic impacts. According to the World Bank, impacts from natural hazards are estimated to cost the country USD800 million per year (World Bank Group, 2021).

Morocco is considered as a hotspot with considerable warming trends of 0.2 °C per decade since the 1960s (World Bank Group, 2022) and these events are only expected to intensify over the coming decades with significant expected impacts on social and economic development.

Environmental degradation and deforestation, as well as impacted water resources, are threats to Morocco's continued development given it is heavily dependent on rain-fed agriculture and poverty reduction efforts, raising the importance of sustainable adaptation and resilience measures. Irregular rainfall is a major source of macro-economic volatility, while the agricultural sector contributes 12% of the national GDP and is the largest employer, accounting for 33% of the population.

Conscious of these challenges, Morocco is one of the few countries to have set adaptation targets as part of its NDCs to the Paris Agreement.

The investments needed to implement the targeted adaptation programmes in the priority sectors of water, forests and agriculture are estimated at USD 40 billion (according to the Nationally determined contributions (NDCs) for Morocco) underlining the need to mobilise the financial sector.

To support this transformation, Bank Al-Maghrib coordinated the implementation of a national roadmap on sustainable finance in 2016 and contributed to the recently issued green finance strategy (Kingdom of Morocco, Ministry of Economy and Finance, 2024).

This new strategy, informed by the study of the current state of climate financing in Morocco, is an essential lever for mobilising the private sector to achieve national climate objectives, while recognising the key role of the central bank, regulators and public authorities.

As a regulator, Bank Al-Maghrib published, in March 2021, its regulatory Directive 5/W/2021 that set out its expectations of banks for the management of climate-related and environmental physical and transition risks. This directive is based on international principles and best practices, especially the NGFS Recommendations, Basel committee principles and the Task Force on Climate-Related Financial Disclosures (TCFD).

In 2022, the central bank performed its first climate risk analysis with the support of the World Bank covering drought, floods and energy transition and the financial impacts on Moroccan banks balance sheets. This work was aimed at raising banking sector awareness of the significance of climate risks.

The study, which is the first of its kind in the Middle East and North Africa region and among the few comprehensive analysis covering both physical and transition risks in emerging markets and developing economies, revealed that over one-third of bank loan portfolios are particularly exposed to climate physical risks, emphasising the importance of adaptation efforts in reducing the intensity and impact of disaster risks.

In line with these efforts, the central bank is contributing to the preparation and adoption of a green finance taxonomy by 2025. This taxonomy is intended to mobilise the full capacity of the financial system towards climate change mitigation and adaptation projects, particularly in the areas of water management, coastal zone protection, construction of climate-resilient infrastructures and natural disaster management preparedness.

e. The Netherlands

The Netherlands is a low-lying delta area with four large rivers and a high population density. About 60% of the Netherlands' land area is below sea level or susceptible to flooding from rivers overflowing their banks. Almost 70% of the population lives in this flood-prone area (De Nederlandsche Bank, 2022).

With climate change increasing the risk of inundation events, adaptation is a top priority for the Netherlands (Kingdom of the Netherlands, 2021). In 2016 the Netherlands adopted its National Adaptation Strategy (NAS). The NAS sets clear guidelines for adaptation action in the Netherlands to prepare for a climate-resilient future. This includes a comprehensive approach to adaptation that integrates climate-resilient policies across all sectors, such as water, infrastructure/mobility, urban and spatial planning, agriculture, nature/biodiversity, health and security. The Netherlands has centres of knowledge on various elements of adaptation that assign a crucial role to nature-based solutions and an ecosystem-based approach.

Part of the national strategy for resilience in water management is the Netherlands' Delta Programme, which involves concerted efforts by central government, the provinces, municipalities, district water authorities, *Rijkswaterstaat* (department of waterways and public works) and a range of NGOs, under the auspices of the Delta Commissioner – the independent government commissioner for the Delta Programme. The Delta Programme focuses on three areas: Flood Risk Management, Freshwater Supply and Spatial Adaptation. All decisions under the Delta Programme, known as Delta decisions, are anchored in national frameworks, such as the Delta Plan on spatial planning.

De Nederlandsche Bank (DNB) and adaptation

Climate change directly affects households and businesses, as well as financial institutions. Through their exposures to real estate in particular, financial institutions are faced with the consequences of physical climate risks. Insurers of buildings are facing rising costs of claims due to extreme weather. Lower property valuations in flood-prone areas affect the banks that have granted the mortgages as well as institutional investors with real estate investments.

In its role as a supervisory authority, DNB expects financial institutions to manage any material climate and environmental risks.[15] Since 2016, DNB has been identifying the scope of sustainability risks affecting the Dutch financial sector and how these risks are managed.

Floods in the Netherlands have the potential to have a significant impact on the Dutch economy and financial institutions and so over recent years, DNB has conducted scenario analysis for flood risk. Two recent DNB studies (2021, 2023) point to a potentially material, though in the short-run most likely manageable, impact for financial institutions. The IMF (2024) has pointed out that climate change could intensify the losses from floods in the Netherlands, putting downward pressure on capital ratios. Therefore, the IMF concludes that flood scenarios under future climate conditions would help to assess the impact of climate change on the one hand and adaptation via the Dutch reinforcement plans for flood protection on the other.

A specific feature of the Dutch context is that damages from major floods are not insurable. The 2021 summer floods demonstrated how such uninsured losses leave the real economy vulnerable to damages. DNB highlighted this topic and provided recommendations for both government and the insurance sector (De Nederlandsche Bank, 2022).

As founder and chair of the Dutch Sustainable Finance Platform, DNB facilitates a dialogue on sustainable finance between the Dutch financial sector, supervisory authorities and government ministries. In 2022, the platform launched the working group on Climate Adaptation, in which experts from the financial and the public sectors cooperate. In their 2023 report Accelerating climate adaptation, the working group analyses both the impact of climate change on the financial system ('outside in') and the contribution the sector can make to climate adaptation ('inside out'), providing recommendations for achieving climate resilience for the financial system, government and business, and sharing good practices of actions that financial institutions can take themselves to stimulate adaptation.

15 In banking supervision, DNB follows the approach of the European Central Bank. For (among others) insurance companies and pension funds, DNB has developed its own supervisory approach and guidance.

f. Rwanda

Rwanda's updated NDC, published in 2020, highlights the critical role of climate adaptation due to the country's vulnerability to climate change. While much of the adaptation strategy has broad development goals, it also has specific financial and regulatory implications for the financial system that are essential for central banks and supervisors to address.

The central bank's role in adaptation is closely tied to the assessment of financial risks arising from climate-related vulnerabilities. In Rwanda, the agricultural sector – particularly at risk from rising temperatures and erratic rainfall – poses significant risks to financial stability due to the heavy reliance on agriculture for livelihoods and credit exposure of financial institutions to this sector. Recognizing this, the National Bank of Rwanda (NBR) is actively involved in overseeing the integration of climate risks into the financial system through mechanisms such as stress testing for agricultural and environmental risks, ensuring financial institutions account for climate risks in their portfolios.

Additionally, Rwanda is in the process of developing a national green taxonomy consistent with recommendation 6 of the 2019 NGFS report "A Call for Action" which encouraged supporting the development of a taxonomy of economic activities. The taxonomy focuses on adaptation activities, with the central bank playing a key role in Phase II of its development. This phase is centered on addressing climate hazards such as flood damage, water stress, and storm damage. The taxonomy will provide a classification system for economic activities contributing to climate adaptation, creating a clear framework for financial institutions to align their lending and investment portfolios with national climate goals. By defining and standardizing what qualifies as an adaptation activity, the green taxonomy will help ensure that financial institutions can properly assess the risks and opportunities tied to climate resilience projects.

For central banks and regulators, a green taxonomy offers a tool for enhancing the supervision and regulation of climate-related financial risks. It can provide a clear benchmark for assessing whether financial institutions are contributing to national adaptation goals and help track the allocation of finance toward sustainable and resilient activities. This is crucial for guiding capital toward investments that bolster the economy's resilience to climate change while managing financial risks.

Another initiative relates to the National Agriculture Insurance Scheme, a public-private partnership that also reflects Rwanda's efforts to adapt and address climate risks in the financial system. The Rwandan government has introduced the National Agriculture Insurance Scheme in partnership with the private insurance sector to support climate adaptation. This scheme, subsidised by up to 40% by the government, protects farmers from losses due to extreme weather events, pests and diseases, facilitating access to financial services and credit to enhance productivity and transform agricultural financing in Rwanda. It provides financial protection to farmers against climate-related risks, thereby reducing potential credit defaults and maintaining financial stability. Financial regulators ensure that such schemes are effectively managed to mitigate the risks of non-performing loans that might arise from climate-induced agricultural losses. Rwanda has also launched the development of an insurance strategy which will, among others, tackle the issue of the insurance protection gap.

The establishment of Ireme Invest, a green investment facility by the Rwanda Green Fund and the Development Bank of Rwanda (BRD), supports businesses focusing on climate adaptation, particularly in sectors such as agriculture, water, and climate-smart technology, and that financial institutions incorporate climate risks into their lending and investment decisions.

Rwanda's strategy intertwines financial stability, risk management, and climate adaptation. Supervisory authorities are tasked with ensuring that financial institutions are resilient to climate risks, with the NBR leading initiatives to harmonize climate risk frameworks across sectors under its regulation.

While Rwanda's climate adaptation efforts are supported by strong government policies, the financial system, guided by the central bank, also plays a crucial role in ensuring that the economy is resilient to climate impacts. Central banks and supervisors are essential to integrating climate adaptation into financial stability frameworks, with the development of national climate and nature finance strategy and the green taxonomy serving as vital tools for ensuring that financial institutions can manage and mitigate climate risks effectively.

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