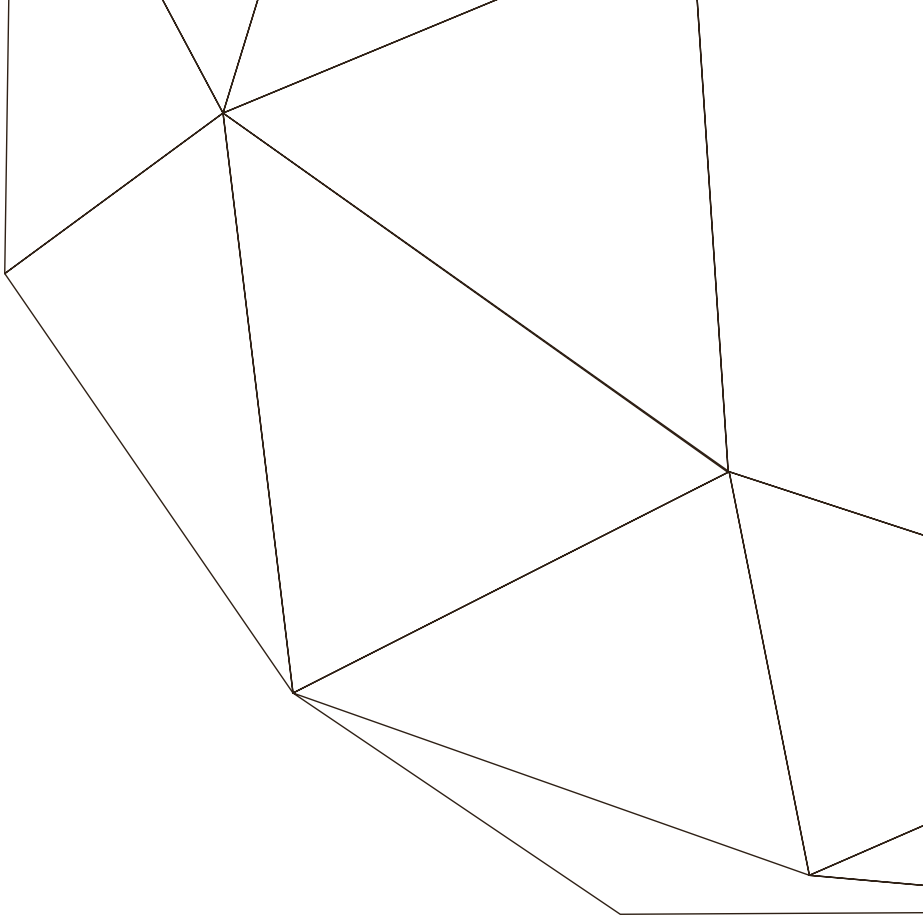

Green Climate Fund working paper No.1

Adaptation: Accelerating action towards a climate resilient future

GREEN CLIMATE FUND | WORKING PAPERS

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List of abbreviations

AE	Accredited entity
E&ES	Ecosystems and ecosystem services
CTCN	Climate Technology Centre and Network
GCF	Green Climate Fund
GDP	Gross domestic product
IA	Integrated Adaptation
ICT	Information and communication technology
IPCC	Intergovernmental Panel on Climate Change
ISDR	International Strategy for Disaster Reduction
IWRM	Integrated Water Resource Management
LDCs	Least developed countries
NAPs	National adaptation plans
NCA	Natural capital accounting
NDA	National designated authority
NDCs	Nationally determined contributions
SDGs	Sustainable Development goals
SIDS	Small Island Developing States
RD&D	Research, development and demonstration
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WASH	Water, sanitation and hygiene
WHO	World Health Organization

Preface

Climate change is an existential threat to all people. The challenges it poses are immediate and urgent. Evidence of ever higher levels of climate risks are mounting, as global temperatures increase, sea levels rise, and glaciers melt. More and more people worldwide are feeling the impacts of water scarcity, heat waves and wildfires, and in some instances catastrophic storms and floods. Vulnerable groups in developing countries, such as coastal communities, smallholder farmers, and the urban poor, are particularly impacted by rising temperatures and climate-related disasters.

We have not yet reached a turning point in greenhouse gas emissions, and there is a clear need for climate action now on both mitigation and adaptation. Each new climate record broken, each new disaster reinforces the urgency for faster and better adaptation and resilience-building.

The Green Climate Fund plays a unique role in turning countries' climate ambitions into climate action and pursuing implementation of the goals set under the Paris Agreement. GCF is a true partnership between developing and developed countries, expressed through 50/50 representation in its governance. One critical dimension of this partnership is the Board's commitment to investing 50 per cent of funding in adaptation action, with a particular focus on the most vulnerable countries including Small Island Developing States (SIDS), Least Developed Countries (LDCs), and African States. GCF has a strong focus on helping developing countries realize the paradigm shifts required to transform development pathways in response to climate challenges, through institutional, financial, socio-economic and environmental investments.

In its initial four years of funding operations, and with a rapid scale-up of capabilities, GCF has reached 97 countries with climate project funding and over 120 countries with climate readiness support. Investments of USD 5 billion from GCF's resources have so far leveraged a total of USD 17.7 billion in climate investments as a result of GCF action. GCF support to climate readiness and direct access to climate financing for countries is also changing the institutional landscape, helping to integrate climate science and forecasting into economic planning and investment decision-making across the developing world. In 2019, GCF is gearing up for its first replenishment. An ambitious replenishment will be key for the Fund to expand its catalytic investments in country-driven transformation.

This publication has been developed as a contribution to adaptation knowledge, from the perspective of climate financing. It provides an overview of adaptation and resilience challenges, the distinction between them, and discusses the avenues that GCF is developing to tackle them, together with countries and many stakeholders including the private sector. Ultimately, we hope this will inform the design and scaling up of more successful adaptation investments. Over the next year, GCF will be launching a series of detailed sectoral guides in its results areas which will include each of the areas covered here: health and well-being, climate information services and early warning systems, agriculture and food security, forests and land use, ecosystems and ecosystem services, water security, climate-resilient infrastructure, and resilient cities.

Through focused investments in these inter-linked sectors, based upon national adaptation policies and plans, we hope GCF can catalyse a paradigm shift in the way countries respond to their citizens' adaptation needs, and build their resilience, working with a large range of partners and stakeholders. GCF has a strong commitment to supporting countries and entities in the transformational changes that are needed now, to adapt, survive, and thrive in a fast-changing world.

My sincere thanks go to everyone across the GCF Secretariat who has contributed to developing this first GCF knowledge product on adaptation.

Yannick Glemarec
GCF Executive Director

1. Introduction and overview: Accelerating action towards a climate resilient future

Adaptation needs are coming into sharp focus as the impacts of climate change are more evident. Increasing numbers of people worldwide are being affected by the higher frequency and severity of water-related disasters, such as droughts, floods, tropical cyclones and storm surges, and heat-related disasters such as heat waves and wildfires. 18 of the 19 hottest years on record have occurred since 2001, based on average temperatures worldwide since such record keeping began.[i] Land-based ice sheets in Greenland and Antarctica are melting ever faster, as are glaciers and ice-caps in mountainous regions. Global average sea levels have risen by 178 mm in the past 100 years and will continue to rise further as the ice melts.[ii]

These changes are linked to the fact that the current greenhouse gas levels in the atmosphere, the highest for 650,000 years, are warming the planet.[iii] Not only global temperature rise, but also oceanic systems and atmospheric systems such as the jet stream are being affected, causing unpredictable and extreme climate variations, and dramatic changes in rainfall patterns. While greenhouse gas emissions keep growing, these climate risks will continue to increase. Some of the changes to our planetary systems are now irreversible. Even when mitigation efforts succeed and carbon emissions begin to fall, many climate effects will persist for millennia.[iv]

Hence, we are facing adaptation challenges that we are only now beginning to grasp in their entirety. The health, livelihoods and lives of billions of people and of their children and grandchildren are at risk. Ever larger numbers of people are losing their homes in climate-related disasters or are forced to take the decision to leave their homes temporarily or permanently, due to climate-related threats to their physical security, food security or water security. The urgency to address adaptation challenges is now inescapable. This publication seeks to explore how we can become more adaptable and resilient, how countries, communities, civil society, the private sector, scientists and other stakeholders can come together to examine solutions to new and unprecedented climate challenges to health, to agriculture, to water supply, to cities and infrastructure, and to the ecosystems upon which we depend.

The good news is that our capacities for global environmental governance, the science of planetary management, and technological developments are also advancing in leaps and bounds. Significant recent milestones include the negotiated decisions reached by the international community in 2015 on the Sendai Framework on Disaster Risk Reduction, the Sustainable Development Goals (SDGs), and the Paris Agreement. The core of the Green Climate Fund's (GCF) mandate comes from Article 2(c) of the Paris Agreement, which "aims to strengthen the global response to the threat of climate change … by making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development".

So, what exactly is climate-resilient development, and what does this mean for countries? And how does this relate to adaptation? This working paper aims to tease out the distinctions between adaptation and resilience, as well as the overlaps, in order to point the way towards systemic change and the possibility of creating paradigm shifts towards more sustainable systems.

The Oxford English Dictionary defines adaptation as "the process of change by which an organism or species becomes better suited to its environment".[v] The United Nation's (UN) definition of adaptation in the context of climate change is much more specific: "Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It

refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change."[vi] Both of these definitions emphasise adaptation as a process of change, in a beneficial direction.

On the other hand, the Oxford English Dictionary defines resilience as "the capacity to recover quickly from difficulties".[vii] Here the focus is on recovery or bouncing back from a shock or a disaster. The UN's International Strategy for Disaster Reduction (ISDR) defines resilience as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions".[viii] Resilience does not necessarily involve any adaptation, if it means simply returning to the status quo.

However, resilience is closely related to the vulnerability of people or communities: the greater their vulnerability to the impacts of climate change, the lower their resilience, and vice versa. Here is where an overlap with adaptation exists. For example, when disaster risk reduction efforts work to reduce people's vulnerability and build their resilience through integrated flood management, improving water supply systems or strengthening agricultural value chains, that is adaptation. By contrast, if people simply rebuild their houses and businesses after a hurricane or a flood in order to live as they did before the disaster, they are demonstrating their resilience, but this cannot be termed adaptation. Post-disaster recovery efforts are adaptive only if they include a transformative shift towards more sustainable systems – a concept of transformative resilience.

Climate-resilient development is therefore development, a process of change in a beneficial direction, that incorporates specific aspects to moderate climate-related damages or to benefit from climate-related opportunities. Climate-resilient development can cover activities building transformative resilience and promoting adaptation. GCF invests in projects and programmes that support either or both of these within its adaptation portfolio, and in addition, many successful adaptation projects include co-benefits for mitigation.

Adaptation thought leadership is about designing the projects which will lead to a paradigm shift and systemic changes in our societies and economies, taking the changing climate into account. This working paper sets out the broad processes and directions which can help to shape climate action, ideas and projects on the ground. Adaptation planning, policy-making, legal and regulatory frameworks and their vital roles in project design are described in Section 2. Successful projects should also be able to provide the benefits to people and the hard evidence needed to feed back into policy-making processes, thereby creating a systemic shift.

The distinction between climate-resilient development and development per se may be defined on the basis of climate science, as covered in Section 3. Where climate change is clearly shown to be increasing the barriers to development, investing in a climate-resilient development pathway makes sense. Private sector responses to climate adaptation, and the strategic thinking about adaptation taking place within the insurance and re-insurance industries are covered in Sections 4 and 5. Thereafter, in Section 6, this publication presents brief sectoral overviews, each of which will in the future be developed into a sectoral guide to support good project design.

All adaptation projects need to be based upon ensuring and promoting people's health and well-being (Section 6.1), either as a major benefit or a co-benefit. All projects also need to be based upon sound climate information, incorporating

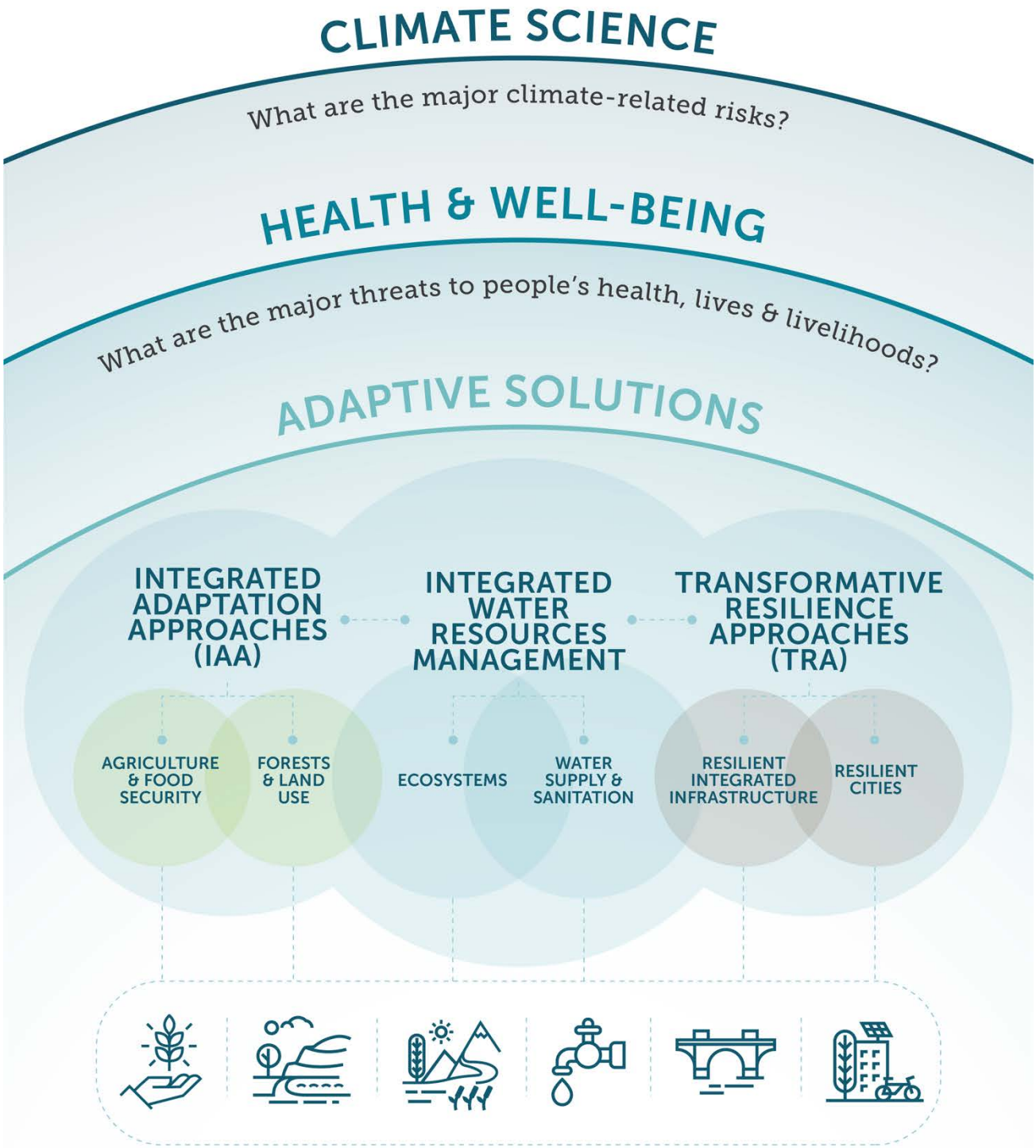
early warning systems of climatic shocks such as floods, hurricanes, tropical cyclones, storm surges, blizzards, heatwaves, wildfires or droughts (Section 6.2). Where early warning systems do not yet exist or climate information is lacking, building weather stations and gathering hydrometeorological data should be incorporated within the project design, to strengthen the national climate observation system. This is an essential basis for gearing up for future climate shocks with a sense of urgency. It can also open the door to new and emerging forms of adaptation support such as forecast-based financing.

GCF encourages integration and "joined-up thinking" linking natural and systemic solutions together with reducing vulnerability more broadly and enhancing the livelihoods of the most vulnerable people. Integrated Adaptation (IA) brings together agriculture and food security (Section 6.3), forests and land use (Section 6.4), ecosystems and ecosystem services (Section 6.5), and water security (Section 6.6), within a holistic landscape-based perspective that covers oceans, land and coastal zones.

Secondly, GCF also supports Transformative Resilience within its adaptation portfolio, linking disaster risk reduction with both hard and soft solutions for resilient integrated infrastructure (transport, energy, water networks) (Section 6.7) and resilient cities (Section 6.8). Such hard and soft resilience solutions need to incorporate Integrated Water Resources Management (IWRM) with ecosystem management and restoration, in order to ensure sustainability. Indeed, IWRM is the bridge linking Integrated Adaptation and Transformative Resilience, from the green to the grey infrastructure. Ecosystem-based adaptation and community-based adaptation also play key roles within disaster risk reduction efforts and Transformative Resilience. Finally, technology and innovation are providing more climate-related tools and solutions at a rapid rate (Section 7). This will help countries to win in the climate race against time.

The adaptation result areas for GCF-funded projects are: i) Most vulnerable people and communities, ii) health and well-being, and food and water security, iii) Infrastructure and built environment, and iv) ecosystems and ecosystem services. The results of all GCF-funded adaptation projects must be monitored and reported through these four categories. The interlinked concepts of Integrated Adaptation and Transformative Resilience as shown in the diagram below are a means towards achieving these ends, in a long-term and sustainable way.

Climate-resilient development will need to aim at protecting vulnerable people and communities from climate-related damages, and to maximise the benefits from climate-related opportunities, in order to boost people's health, prosperity and livelihood opportunities. GCF's role is to help countries prepare for this climate-resilient future. The adaptation portfolio under GCF's first replenishment aims to support countries and entities to realise their projects and programmes and transform their systems, in order to adapt to climate change and become truly climate-resilient.


CLIMATE SCIENCE
What are the major climate-related risks?
HEALTH & WELL-BEING
What are the major threats to people's health, lives & livelihoods?
ADAPTIVE SOLUTIONS
INTEGRATED ADAPTATION APPROACHES (IAA)
INTEGRATED WATER RESOURCES MANAGEMENT
TRANSFORMATIVE RESILIENCE APPROACHES (TRA)
AGRICULTURE & FOOD SECURITY
FORESTS & LAND USE
ECOSYSTEMS
WATER SUPPLY & SANITATION
RESILIENT INTEGRATED INFRASTRUCTURE
RESILIENT CITIES

2. Adaptation planning to catalyse finance for implementation of country priorities

GCF support for the formulation of adaptation planning processes is helping countries strengthen decision-making based on best available science and meaningful stakeholder engagement. The focus is on catalysing the finance countries need to adapt to the potentially devastating effects of climate change.

The Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) at its 19th meeting invited GCF to consider how to improve access to financial support for the process to formulate and implement national adaptation plans (NAPs). In May 2016, the GCF Board decided to expedite funding of up to USD 3 million per country, in order to support the formulation of NAPs and/or other national adaptation planning processes.

These resources (termed the Readiness Programme) are providing a crucial boost to national and local adaptation planning processes that strengthen public and private decision making, based on best available climate science and meaningful stakeholder engagement. GCF support for adaptation planning is also helping countries develop the financing strategies, attract public and private adaptation investments, as well as measure the impact over time. Adaptation planning processes produce, consolidate, communicate and use climate information as the evidence base in the design of programmes and projects for GCF and other sources of climate finance.

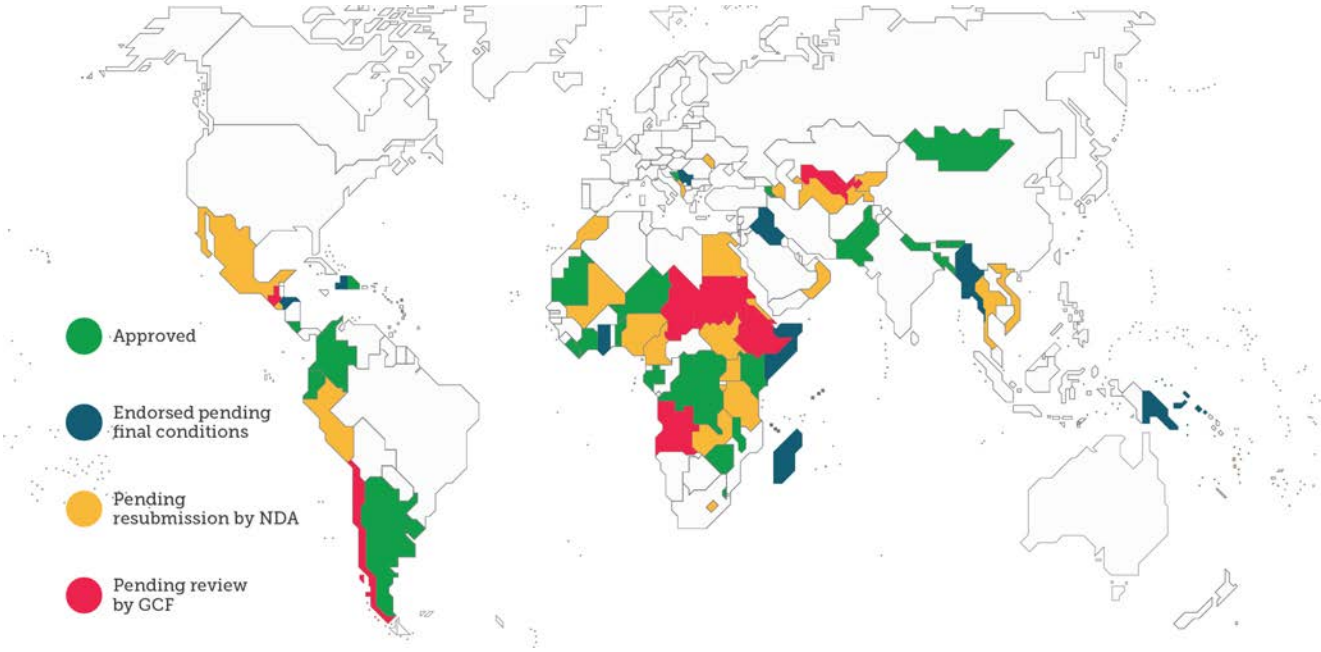
Although implementation of GCF support is preliminary in several countries, valuable insights are emerging. Changing and strengthening

OUTCOME 1	**OUTCOME 2**	**OUTCOME 3**	**OUTCOME 4**
Adaptation planning governance and institutional coordination strengthened	Evidence basis produced to design adaptation solutions for maximum impact	Private sector engagement in adaptation catalyzed	Adaptation finance increased
- Inter and intra-institutional coordination and decision-making mechanisms - Stakeholder engagement frameworks and agreements - Adaptation impact monitoring, evaluation and learning systems - National, sub-national and/or sectoral plans	- Climate hazard impact, vulnerability and risk studies - Consolidation and sharing of climate studies - Communication to relevant public, private and civil society decision makers and other stakeholders	- Policy guidelines and regulations to remove barriers and incentivise adaptation investment - Private sector actors engaged in national, sectoral and/or sub-national adaptation planning - Adaptation planning for climate resilience of individual businesses and supply chains - Technical support to develop financial products for private investment and insurance for climate resilience - Marketplaces and other means of matching private financiers with adaptation solutions	- Financing strategies for specific adaptation priorities - Project and programme concept notes targeting a range of sources including the GCF - Systems for prioritzying adaptation project ideas - Systems for tracking adaptation finance

policies to adapt to climate change may also involve the necessary changes in legislative and regulatory frameworks, which are unique to each country. With the benefit of learning based on initial proposals and early implementation, GCF review criteria and examples of good practice are detailed in the GCF Readiness and Preparatory Support Guidebook. Countries can access resources for their adaptation planning processes through the GCF Readiness Programme for any of the following outcomes and outputs, based on their unique context.

64 percent of the resources for approved adaptation planning proposals to date are for Least Developed Countries (LDCs), Small Island Developing States (SIDS), and African States.

Figure 1 status of countries accessing GCF resources for adaptation planning processes



Status	Submitted	Approved + Endorsed
27 March 2019	74	35 (26+9)
1 January 2019	40	8 (3+5)

3. Basing adaptation projects on climate science

A strong climate science argument must be the basis for the design of climate projects. Evidence from recent climate disasters includes the 2019 cyclone that hit several countries including Mozambique, Malawi and Zimbabwe, which caused massive destruction of livelihoods and infrastructure with the number of lives lost and missing still to be confirmed.[ix] This event and many others have demonstrated that standard development approaches cannot withstand the increasing impacts of current and future climate variability and change. One of the major challenges in distinguishing between a development project and a climate project is the scientific basis of the project design. Whereas standard development projects do not mainstream climate risks in their design, a climate project must first of all establish the climate risks of the project to make the project design climate-resilient against current and future climatic extremes.

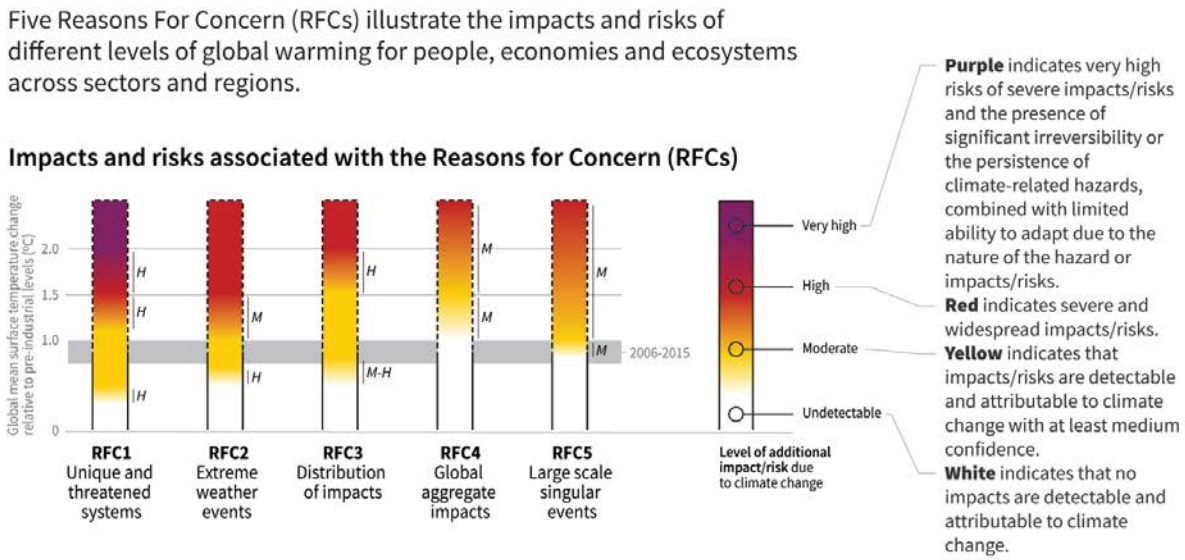
To access available climate finance and, most importantly, the USD 100 billion per annum by 2020 articulated in the Paris Agreement, climate projects must demonstrate a strong basis in climate science to enable the determination of the additionality and concessionality of finance that can be accessed. The major challenge is demonstrating the robustness of the science surrounding the project design and quantifying uncertainties associated with the data and approaches. To undertake impact and risk assessment on a given sector, one will have to quantify the uncertainties in model predictions associated with cascading uncertainties in the scenarios, and the impact model for the sector. Recent developments in climate and decision sciences enable the use of ensemble predictions (statistics from an ensemble of models) to quantify these uncertainties, in order to enable robust decision-making. As a result, climate extremes like tropical storms and their impacts are being more accurately forecast to enable early action to secure lives, livelihoods and assets.

The "Reasons for Concern" of the Intergovernmental Panel on Climate Change (IPCC) could be a very important articulation of the climate risks and impacts for project design. There is strong evidence that global warming is having devastating impacts on human and natural systems. The risks associated with global warming have been summarized by IPCC into five "Reasons for Concern"[x] elaborated below:

1) Risks to unique and threatened systems (e.g. tropical glaciers, coral reefs, and indigenous communities);
2) Risks associated with extreme weather events (e.g. floods, tropical storms, heat waves and fires);
3) Risks with the distribution of impacts as certain regions and groups are at greater risk of climate impacts;
4) Risks associated with global aggregate impacts related to the economic and ecological effects of climate change (e.g. impacts on agricultural markets and impacts on human health); and
5) Risks associated with large-scale singular events pertaining to irreversible changes (e.g. the melting of the Greenland and West Antarctic Sheets, and a large, rapid release of methane into the atmosphere).

These five reasons for concern could form the basis for establishing climate impacts and risks for project design as illustrated in Figure 1.

Figure 2 IPCC five Reasons for Concern[xi].



Determining the most appropriate intervention entails a better understanding and articulation of the reasons for concern, which should thereafter be contextualized, based on regional, sectoral, national and local considerations.

4. The role of the private sector in adaptation action

Engaging the private sector in adaptation has been challenging due to various financial, economic, and social factors. GCF is uniquely positioned to unlock the potential of private capital via its innovative instruments and will continue to explore ways to scale up adaptation activities working together with private sector partners.

There are currently several efforts to estimate and determine the climate change adaptation costs up to 2050 and beyond. By 2030, it is estimated that adaptation costs could be in the range of USD 140 to USD 300 billion per year, and USD 280 to USD 500 billion by 2050.[xii] As there is a high level of uncertainty related to this cost estimations, the actual finance gap for adaptation could be much greater than expected in the next 30 years and beyond, making current and projected public resources limited and suggesting the need to mobilize private sector and institutional investment crucial to addressing adaptation finance needs.

GCF aims to directly and indirectly finance private sector mitigation and adaptation activities at the national, regional and international levels. Through engaging private sector partners, GCF acts as a catalyst for funding high impact, transformative and innovative climate projects in developing countries. GCF offers long-term funding through various instruments and concessionality structures where necessary to de-risk high impact projects. These investments are deployed through equity, debt, guarantees and grants, which can be combined into a variety of financing structures, including project-based special purpose vehicles, direct equity, debt funds, fund-of-funds, structured finance vehicles and/or on-lending.

Engaging the private sector in adaptation actions has been challenging as there are several existing barriers to overcome. These include:

- A clearly defined project scope where the adaptation component is made explicit;
- A credible project proponent or counterparty;
- A revenue stream and commercial investment return;
- Adequate project scale;
- An accepted framework for allocating financial benefit (value added); and
- Effective coordination across different levels of government.[xiii]

Countries that are most vulnerable to adverse climate change effects, namely LDCs and SIDS, are facing even greater structural barriers. These barriers are more challenging to overcome due to underdeveloped or non-existent markets for adaptation products, and a lack of robust and well-defined business models for adaptation, with the possible exception of insurance. To create an incentive for the private sector to participate in adaptation activities, concessional funding sources need to be secured during the early phase of business opportunities.

This is where blended finance can help to create impact. Potential sources can include a combination of public and private sources from the following: climate finance providers, such as GCF, multilateral donors, philanthropy, endowments, innovative finance (remittance, crowd-funding, etc.), public sector (governmental and sovereign funds), and private/commercial players (specialized capital pools, early stage investors, local banks, local microfinance etc.). Adaptation investments should not only be measured through revenue generation, but also through loss avoidance derived from increased resilience to climate induced events (e.g. tourism and infrastructure).

Case study: Investing in Low Emission and Climate Resilient Agriculture in Africa

Agriculture is a major industry in East and West Africa and the majority of farmland is managed by smallholder farmers who are highly vulnerable to the impacts of climate change. Acumen, through an equity fund, will make investments in companies to improve climate resilience to ensure long-term sustainable increases in agriculture productivity and incomes for smallholder farmers. The fund will support pioneering and early-growth innovative agribusinesses that enhance the climate resilience of smallholder farmers. GCF has committed USD 26 million in equity and technical assistance aimed at ensuring long-term sustainable increases in agriculture productivity and incomes for smallholder farmers and catalysing private sector investments in climate resilient agriculture. At scale, this project is expected to benefit over 10 million smallholder farmers in East and West Africa.

Building on the experience of mitigation finance is also identified as a potential solution for increasing investment in adaptation, particularly by using aggregation models and platforms, in order to achieve investment scale. [xiv] Creating an enabling environment through consistent policy and regulatory support is also key.

There are existing opportunities to tap into innovative technologies that promote financial inclusion, such as mobile phone payment and modern banking systems, with the potential to address a large segment of the targeted clients. Non-traditional economic sectors have also begun to grow, such as mobile health, responsible tourism and coastal protection. Pre-requisites to further their development include: an increased understanding of the role of blended finance in supporting sector-specific business opportunities, increased risk coverage for early stage finance, systematic capture of lessons learnt from monitoring and evaluation, and markets insight to be shared with financial institutions locally, regionally and internationally.

5. Insurance and Climate Finance

The Paris Agreement, through Article 8, recognizes the importance of comprehensive risk management strategies, including risk insurance facilities, climate risk pooling and other insurance solutions. The UNFCCC, through its Standing Committee on Finance, has also increased its focus in recent years on insurance and risk transfer instruments to address climate challenges. GCF considers insurance to be a key modality for pursuing innovation, impact and scale in adaptation finance and is building on a portfolio that leverages insurance expertise across sectors and developing countries.

The insurance and reinsurance industry has been establishing the economic case for climate action and helping to shape the global policy agenda. Through underwriting, investment, advocacy, research and technical partnerships, insurers support a broad range of stakeholders across public and private sectors. Their access to climate data and extensive capabilities in predictive hazard and loss modelling has afforded insurers a unique ability to design innovative risk transfer products and instruments. Global reinsurers have been invaluable in building knowledge on climate resilience and risk reduction and transferring lessons through their local networks. By setting pricing signals and quantifying the acceptable upper bounds for climate risk, insurers have also strongly influenced the design, financing and implementation of investments and helped bring to fruition high-impact interventions. These factors make the insurance and re-insurance sector a natural partner for GCF in adaptation finance in developing countries.

GCF's adaptation portfolio includes projects in weather index-linked agricultural insurance, climate information and early warning systems, and capacity building to regulators, insurers, lenders and other stakeholders. GCF is actively seeking to develop and deploy insurance instruments at the micro, meso and macro levels to support transformative resilience in hard infrastructure and urban environments, as well as integrated adaptation through soft and nature-based measures in the context of health and well-being, agriculture, livelihoods, food systems and ecosystems. There are significant untapped opportunities to scale-up engagement with insurers and development partners in early warning systems, and to design and implement individual projects; de-risk adaptation portfolios of financial institutions; and develop insurance modalities that extract and enhance co-benefits in highly correlated sectors, such as water, sanitation and health. GCF is also open to debt and equity investment in risk and insurance facilities focusing on climate adaptation.

Insurance-linked interventions can significantly leverage finite climate funding and help achieve a greater balance between mitigation and adaptation action. In public sector applications, insurance also embeds proactive ex-ante measures in adaptation planning and provides sovereign and sub-sovereign governments with a broader range of risk-financing choices that tap into global expertise and capital. Instruments such as microinsurance are particularly well suited to reach vulnerable individuals and households, address gender impacts of climate change, and contribute to nascent social safety systems in LDCs. In SIDS, particularly in the Caribbean and Pacific regions, catastrophe risk pools have infused capital into domestic insurance markets, made risk transfer viable and attractive for governments, and fostered regional coordination in policy responses to climate change. As much of the technical and financial resources of the global insurance sector reside in the private sector, insurance can strengthen public-private partnerships in adaptation and catalyse risk reduction as a commercial imperative.

Case study: Increasing the Resilience of Vulnerable Rural Households in Senegal to Climate-related Risks

Working with the **Government of Senegal, GCF and World Food Programme's R4 Rural Resilience Initiative** will support risk-reduction activities for water and soil conservation, increased water availability, livelihood diversification and training on climate-resilient practices. These activities will be complemented by **weather index insurance** that will transfer risk of crop failure to the Senegalese and international insurance markets. Through an **Insurance for Assets scheme**, the Government of Senegal partly pays premium on behalf of food-insecure households in return for their participation in small-scale risk reduction asset creation activities, with the goal of transitioning the insurance into a revenue-based model. [The project supports **526,500 beneficiaries over four years**.

Experience shows that insurance is most effective where it is integrated into broader resilience-enhancing interventions. It is important to reconcile its limitations. While critical in financing damages from rapid onset risks such as natural disasters, insurance is often unable to address gradual onset risks such as sea level rise and inundation of low-lying islands. Innovative climate insurance facilities are being piloted worldwide - ranging from agricultural to sovereign catastrophe risk pools – but many need to be better integrated into national and regional adaptation strategies and prove long-term financial viability. Finally, rising economic losses from natural disasters, particularly urban and coastal flooding, are calling into question the viability of public insurance schemes and prompting insurers to consider withdrawal from high-risk areas.

Insurers represent over USD40 trillion in global assets under management, and alongside other institutional investors, are increasingly taking climate considerations into account when making investment decisions.[xv] Major reinsurers have begun to disclose climate risks and have committed to divest their portfolios of carbon-intensive investments. A shift in insurers' capital allocation towards resilient investments can potentially unlock a vast pool of capital for mitigation and adaptation finance.

Much of the future growth in the global insurance sector is expected to occur in developing countries, where gross domestic product (GDP) growth is leading to rising insurance penetration and density and expanding the sector's role in in domestic capital accumulation and investment. This presents insurers with the opportunity to innovate to support climate action, and to embed adaptation action in the development pathways that developing countries will follow for years to come.

6. Sectoral approaches to adaptation investments

6.1. Health and well-being

Adaptation measures for the health sector will improve health directly and indirectly, for instance by climate-proofing health systems, and addressing health determining sectors such as cities.

The UNFCCC states that the adverse effects of climate change have *"significant deleterious effects"* on many aspects of natural and socio-economic systems, including human health and welfare. The Paris Agreement states that when acting to address climate change, Parties should *"respect, promote and consider their respective obligations on…the right to health…"*. Good health and well-being are also crucial for achieving sustainable development and are key components of the 2030 Agenda for Sustainable Development.

Human health, simply defined by the World Health Organization (WHO) as "the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity",[xvi] and well-being, composed of different dimensions and often associated with overall life satisfaction, depend on sectors including water supply and sanitation, land use management, ecosystems, agriculture, infrastructure, energy and transportation, among others. Climate change affects health and well-being directly from more frequent and intense heat waves, floods, droughts and other extreme weather events. These climate hazards result in an increase in human mortality and morbidity and can destroy health facilities and disrupt services. The direct damage costs to health resulting from climate change is estimated to be USD 2 to USD 4 billion per year by 2030, excluding health-determining sectors such as agriculture and water.[xvii]

Indirectly, climate change also affects health and well-being through environmental and societal systems that are being negatively affected by climate change, such as the increase and spread of vector-borne diseases, undernutrition, water insecurity and the loss of livelihoods stemming from extreme climate events. Between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year from malnutrition, malaria, diarrhoea and heat stress.[xviii] Population groups including the socially disadvantaged, children, the elderly, the chronically ill and disabled people are particularly vulnerable to the health impacts of climate change, especially in regions with weak health protection systems and little adaptive capacity.

Despite the significant direct and indirect health impacts of climate change, there are very limited investments and interventions in climate finance aiming to prevent and reduce climate-related health risks. While health is clearly prioritized in national commitments and emphasized in guidance provided by UNFCCC and WHO, still only 0.5 per cent of multilateral climate finance has been allotted to health projects[xix]. Currently, there are few projects in the portfolio of GCF that directly address the health impacts of climate change; however, GCF is seeking to fill this gap and catalyse a paradigm shift towards climate-resilient development, by ensuring strong consideration of health impacts in all GCF interventions.

Health and well-being components can be integrated into sectors within both GCF mitigation and adaptation themes. For adaptation in particular, direct health benefits can be realized through resilient infrastructure for health facilities such as hospitals and warehouses, and the integration of health in early warning systems. At the same time, building on investments in adaptation interventions can maximize health co-benefits and reduce negative consequences, if designed and implemented with health adaptation strategies such as a systems

approach. Indirect health benefits can also be gained through improved water supply, sanitation and hygiene projects, which can reduce spread of vector-borne diseases. Climate-resilient agricultural practices can also contribute to reducing undernutrition. People's health and well-being are key to any urbanization approach that requires innovative, integrative and intelligent transformations in all sectors of the urban system.

GCF can help to mainstream health considerations not only across climate-related interventions but also across policies, legislation and regulatory frameworks, with a focus on equity and inclusiveness.

6.2. Climate information and early warning systems

Recognizing the importance of robust climate information and early warning services for climate action, the Paris Agreement (sub-paragraph 7(c)) calls for "…strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision-making…".

Robust climate information and early warning systems are key to ensuring low-emission, climate-resilient development. Climate actions to limit global warming to 1.5˚C will require new policies, technological innovations, attitudinal changes and ramping up adaptation and mitigation financing, all of which should be informed by robust climate information and early warning services. Existing information sources, such as the IPCC Assessment Reports, give a clear picture of climate impacts and risks at the global and regional scales. However, adequate information at the national and local scales, necessary to provide strong scientific basis for adaptation projects, remains limited. Lack of a strong climate science basis for projects could lead to maladaptation, loss of investments and increases in long-term climate risks. This is the gap that GCF investments and interventions in the focus area of climate information and early warning systems seek to address.

One of the core requirements of the Paris Agreement calls for urgent efforts to address and strengthen the hydro-meteorological capacities of countries. However, the technical capacity of many developing countries is inadequate in terms of both hardware and software, and past projects have not sufficiently addressed hydro-meteorological capacity to address climate challenges. Currently, the level of investments needed to transform effective production and delivery of climate information and early warning services remains insufficient.

Paradigm shift and transformational change in this sector will be realized when projects include interventions that strengthen social resilience, as well as adopting technological innovations in ICT revolution such as cloud services, internet of things and big data analytics to deliver efficient and effective services across a range of spatio-temporal scales and decision timelines. For projects to have create paradigm shift and have a truly transformational impact, GCF seeks to advance the following considerations and areas of interventions:

- Enhancing the use of climate science will lead to quality project design and effective implementation on the ground
- Innovation in e-infrastructure and predictive analytics are key to providing robust climate information and early warning services
- End-to-end multi-hazard impact-based early warning systems are more effective and efficient in reducing long-term disaster risks
- Climate risk reduction strategies are key to securing lives, livelihoods and assets of vulnerable communities
- Project alignment with the Global Framework for Climate Services will improve efficiency and effectiveness of hydro-meteorological services
- Quality management and business delivery strategies will improve profitability and sustainability of hydro-meteorological services

Institutional collaboration through catalysing multi-institutional and trans-disciplinary expertise at the global level will ensure that the best available climate information and its applications, services and products are widely available to all countries.

The scale and intensity of current and projected impacts must be matched with an equal measure of commitment to climate action through robust evidenced-based science, innovative technologies, policies and the urgency of political leadership to manage the threats posed by dangerous climate change. GCF aims to

contribute to this by mobilizing financial resources at scale, to support the design and implementation of transformational projects in climate information and early warning systems.

Case study: Programme for integrated development and adaptation to climate change in the Niger Basin

Mitigation potential: 7,000,000 tonnes of CO_2 equivalent avoided
Beneficiaries: 14,000,000 direct and indirect beneficiaries
Total financing: USD 209.9 million
GCF contribution: USD 67.8 million
Implementation period: 6 years

The programme, co-financed by the African Development Bank, seeks to strengthen resilience of the population, livelihoods, ecosystems and natural resources in a region characterized by extreme drought and famine in Benin, Burkina Faso, Cameroun, Chad, Ivory Coast, Guinea, Mali, Niger and Nigeria. Of these countries, seven are highly indebted with projected adaptation cost of 1-10 percent of GDP. Social, economic and environmental benefits could be very significant with opportunity to leverage on well-established high-level political buy-in to demonstrate value of GCF in climate action.

6.3. Resilient Agriculture for Livelihoods and Food Security

The Paris Agreement refers in its preamble to "safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change". Agriculture and food security are highly prioritized in the Nationally Determined Contributions (NDCs) of countries. Among those indicating priority areas for adaptation, 93 percent identified the agricultural sector as a priority.[xx]

Agriculture and food security provide the main source of livelihoods, food and incomes for 78 percent of the world's poor people living in rural areas.[xxi] Agriculture is a key sector for developing countries where 50-70 percent of population depends on rainfed agriculture for their livelihoods.[xxii] Smallholder farmers produce approximately 70 percent of the world's total food requirements, and global food demand is projected to increase by at least 60 percent in 2050 above 2006 levels.[xxiii] Hence, smallholder farmers are crucial to the world's food security, while at the same time one of the most vulnerable groups to the impacts of climate change.

Agriculture in developing countries is extremely vulnerable to climate change, as increasing temperatures, changing rainfall patterns, rising sea levels, increasing climate variability and more climate extremes such as droughts and floods all negatively affect crop, livestock, aquaculture, and fisheries. Crop production will be affected by climate change through water scarcity, the shifting spread of pests and diseases, changing soil conditions, and the different lengths of growing seasons. These impacts result in many places in food insecurity, vulnerability, poverty, non-resilient livelihoods, increased gender inequality and migration. Appropriate adaptation measures need to include long-term options to increase food production under changing climate conditions, to avoid climate change impacts leading to great food insecurity and poverty.

GCF seeks to support innovative solutions towards food security, resilience building and climate risk management. In the long term, these investments will accelerate rural transformation in developing countries where the agriculture sector is a predominant source of livelihoods, and will result in social, economic and financial opportunities for smallholders, making them part of the solution to the challenges of climate change and enabling them to adapt and build their resilience. As climate impacts are specific, it is vital to understand the local context when considering investments into climate resilient agriculture. Incremental adaptation efforts may not be sufficient to protect assets, livelihoods and food security, and more transformational change or a paradigm shift will be required.

Agriculture and food security sit at the nexus of adaptation, mitigation and sustainable development. Most NDCs identify agriculture as a key sector for both adaptation and mitigation. There are many farming practices that can achieve effective adaptation and mitigation to climate change, while also promoting development co-benefits such as reduction in poverty and the empowerment of women. As women contribute significantly to the agriculture sector accounting for 40-60 percent labour contribution, the differentiated roles and therefore vulnerabilities of women and men to climate change impacts on the agriculture sector need to be taken into consideration.[xxiv] It is also important to note that agriculture and food security have synergies across multiple sectors, including forestry, ecosystems, water, renewable energy, climate information and early warning systems. These synergies need to be capitalised on to bring greatest impacts for adaptation and mitigation.

GCF will continue to work with partners to support the development and improvement of

climate-resilient practices, crops and seeds, and the development of technologies that are built around the needs of farmers, to increase uptake and adoption of climate resilient technologies and tools. Many projects supported by GCF aim to create enabling environments to tackle the underlying vulnerabilities of farmers to climate change, by supporting countries to remove barriers along the entire value chain. GCF is seeking to continue its support by further incentivising planning and investment in climate-resilient and low-emissions agricultural value chains, encouraging the participation of local communities, women and indigenous peoples in innovating and implementing new technologies and practices, continuing to explore programmes of financing for agricultural productivity impacted by climate change by attracting public and private sector investment, and deploying at scale climate information and services tailored for agriculture and agricultural insurance products that enable risk-management.

Case study: Climate-Friendly Agribusiness Value Chains Sector Project in Cambodia

Mitigation potential: 240,000 tonnes of CO_2 equivalent avoided
Beneficiaries: 1,365,000 direct and indirect beneficiaries
Total financing: USD 141.39 million
GCF contribution: USD 40 million
Implementation period: 6 years

This collaborative project by GCF and the Asian Development Bank will target four provinces in Cambodia, including Kampong Cham, Tbong Khmum, Kampot and Takeo provinces, to improve climate resilience and reduce the climate footprint at each stage of the agricultural value chain. In addition to its climate vulnerability, Cambodia's agricultural value chains remain fragmented and not well developed because of critical infrastructure gaps and a range of capacity and policy constraints. The project will enhance the resilience and productivity of crops and increase agricultural competitiveness and household incomes in the targeted provinces.

6.4. Forests and Land Use

It is estimated that more than 1 billion people worldwide rely on forests for their livelihoods[xxv] *When farming systems fail to deliver due to climate change impacts, forests provide food, fodder and fuel to millions of rural poor and vulnerable communities. Forests also contribute to regulating water, soils and microclimate for enhancing resilient and productive landscapes.*

Internationally, the role of forests to mitigate climate change is recognized explicitly in the Paris Agreement. Although climate policies have historically treated adaptation and mitigation strategies separately, the forest and land use sector needs to be understood as a natural connecting ground for both strategies. Global discussion under the UNFCCC[xxvi] have invited consideration on alternative policy approaches such as joint mitigation and adaptation for the integral and sustainable management of forests. GCF recognizes the mitigation and adaptation benefits provided by forest-related interventions in its projects and programmes. Currently, several developing countries have defined forest-specific adaptation goals under their NDCs, and many of them imply increasing forest landscapes resilience.

Forest-related interventions cannot be understood as standalone actions. Forests need to be perceived as key components of a wider landscape to be sustainably managed and conserved under a changing climate in order to meet development needs and achieve environmental sustainability. This integrated approach to forest management has already been put forward by many funding and implementing agencies, and various collaborative efforts demonstrate the validity and cost-efficiency of these integrated interventions. GCF seeks to join these collective efforts, while fostering coherence and complementarity between financing sources supporting both mitigation and adaptation efforts in forest landscapes.

On forests and adaptation, two different but interrelated conceptual approaches need to be acknowledged: firstly, as forests are living ecosystems, climate change imposes additional impacts on forest landscapes and their dynamics. Changes in forest extent, structure and composition through time are expected. This means that forest functions, which are key for the provision of ecosystem services, such as water regulation, carbon sequestration, biodiversity, and soil conservation, are also impacted. Secondly, many vulnerable populations and their livelihoods are forest and landscape-dependent. Hence, forests are to be considered as natural assets for increasing resilience and as safety nets.

Forest-based adaptation solutions need to attract the private sector to unlock the potential for increasing resilience and to reduce climate change vulnerability. Although there seems to be a limited number of experiences to demonstrate increased financial benefits from forest-based adaptation experiences, GCF seeks to engage with the private sector to go beyond discussions solely relying on financial analyses and risk-return profiles. Effective approaches to foster private sector involvement for forest-based adaptation involve:

1) capturing as far as possible all the multiple forest landscape values (i.e. timber, non-timber forest products, ecosystem services),
2) understanding the direct and underlying causes of deforestation and forest degradation under a changing climate context (e.g. increasing productivity of economic activities imposing pressures on the standing forests with expected shifts in their ecological niches),
3) increasing visibility of avoided loss, damages and related costs for forest landscapes-based economic activities when facing climate risks threatening the natural capital source (e.g. landslides related to forest cover loss and precipitation intensity increase causing damages to hydro-energy plants).

4) ex-ante trade-off analysis of ecosystem services expected to be enhanced prior to defining investment profile and based on interventions' objectives (e.g. upstream forest restoration enhancing water regulation for small-scale agricultural purposes).

GCF is already supporting actions that incentivize resilient forest-based value chains as part of a wider landscape approach, as well as climate change mitigation interventions that demonstrate their effects on building resilience.

Case study: Development of Argan orchards in degraded environments in Morocco

Mitigation potential: 604,200 tonnes of CO_2 equivalent avoided
Beneficiaries: 26,000 direct and indirect beneficiaries
Total funding: USD 49.2 million
GCF contribution: USD 39.3 million
Implementation period: 5 years

Argan oil's market boom in the cosmetics and food industries, coupled with the impacts of climate change upon Argan tree regeneration, have imposed additional pressure on the natural forests of the Arganeraie Biosphere Reserve in Morocco. These native and endemic forests are key ecosystems for sustaining the livelihoods of rural communities in this desertified area. This innovative project, proposed by the Agency of Agricultural Development of Morocco, seeks to increase their resilience by enhancing the value of the forest stands through the establishment of 10,000 hectares with Argan trees under orchards (i.e. arganiculture); and by linking these organized local producers -especially women- to the Argan value chain, thus increasing the niche market value of Argan-based products, supported by organizational capacity building, and research and development.

6.5. Ecosystems and ecosystem services

Ecosystem services form the foundation of all endeavours of human society, from providing fresh water, to supporting agriculture, fisheries, timber from forests, waste processing, and cultural and aesthetic values. The thematic area covers all ecosystems and ecosystem services, minimizing the impact of climate change on the provision of these essential services to all humanity.

An ecosystem is a dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit.[xxvii] Ecosystem services are properties or processes of ecosystems that confer direct or indirect benefits to humans.[xxviii] Following the Millennium Ecosystem Assessment, ecosystem services can be classified into four categories, namely provisioning services, which include food, water, timber and genetic resources; regulating services such as the regulation of climate, floods and waste treatment; supporting services such as soil formation, pollination and nutrient cycling; and cultural services such as recreation and aesthetic enjoyment.[xxix]

The thematic area of ecosystems and ecosystem services (E&ES) encompasses all natural environments and their productive uses. This can range from environments not directly impacted by anthropogenic activities – such as remote rainforests, alpine regions or coral reefs – to environments that are more intensively managed – such as agricultural areas or managed forests for timber production. As there are thematic areas within the GCF Results Management Framework specifically addressing agriculture and food security, forest and land use, and water, the emphasis in this thematic area is on natural or less intensively managed environments.

With increasing impacts of climate change, there is growing concern about the provisioning of ecosystem services in the future.[xxx] The uneven distribution of climate impacts also increases the vulnerability of developing countries, particularly the less developed countries and SIDS.

Critical opportunities exist in E&ES for adaptation investment. E&ES promotes a holistic approach to managing natural resources. As elements of ecosystems are intricately connected with feedback loops, it would be difficult, if not impossible, to achieve climate-resilient development pathways systematically and effectively without considering E&ES within climate projects.

E&ES provides a key buffer to human livelihoods against climate shocks, such as floods and droughts, with co-benefits of storing carbon. By putting an emphasis on the services that natural ecosystems provide, E&ES promotes the harmonization of and mutually beneficial solutions for ecosystem vitality, economic growth, and social inclusion. Natural Capital Accounting (NCA) is an effective tool that can communicate the value of ecosystem services to the public and decision-makers. NCA makes the value of ecosystem services explicit, identifying and quantifying the contributions of these services to the national economy so that considerations of ecosystem health and quality can be assessed and evaluated in the same framework as other indicators. NCA can also provide better measurement of progress, informing a range of policies as well as public perception. Taking account of ecosystems and their services promotes integrated adaptation rather than maladaptation, going beyond damage control and contributing to building resilience to climate change.

The portfolio of GCF displays the wide range of topics that fall under E&ES, often in combination with other result areas such as vulnerable communities, water management, agriculture and food security, and forestry and land use. As an adaptation result area, projects in E&ES can address multiple and interconnected issues, with

a common thread in building integrated adaptation, and increasing resilience against climate change for the natural environment and the people that depend on it. Common elements in funding proposals for E&ES include activities aimed at the quantification, valuation and attribution of ecosystem services and NCA, all of which contribute significantly to the exit strategy of the project and the sustainability of the investment over the long term.

Case study: Scaling up climate resilient water management practices for vulnerable communities in La Mojana, Colombia

Beneficiaries: 405,625 beneficiaries
Total financing: USD 117.2 million
GCF contribution: USD 38.5 million
Implementation period: 8 years

This project, proposed by the United Nations Development Programme and executed by the National Adaptation Fund of Colombia, restores the natural dynamics of a wetland in the interior of Colombia, along the Magdalena river. Past development efforts focused on making the land productive and regulating the flow of the river, but climate change is impacting the hydrology, leading alternately to prolonged droughts that are not buffered by the former wetland, and flooding during the rainy season that is threatening downstream urban areas. Restoring the natural wetland functioning as a sponge, soaking up water, safeguards the livelihoods of the local communities through an improved availability of fresh water throughout the dry season and reduced flooding downstream. The interventions are all based on Ecosystem-based Adaptation, leading to more resilient communities.

6.6. Water security

Water security is the capacity of a population to safeguard sustainable and resilient access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability.[xxxi]

Water resilience is a very high priority for adaptation in developing countries, with widespread cross-sectoral impact, and particularly significant for SIDS, water-scarce and drought-prone regions, fragile mountain environments, coastal and delta regions, as well as megacities.

Most developing countries face water-related challenges, either due to sea level rise, melting glaciers and permafrost, changing rainfall patterns and extreme events, floods, or droughts and desertification. Significant challenges need to be addressed in water resource management, efficiency of use, agricultural irrigation practices, wastewater treatment and sanitation. It is estimated that there will be a 40 percent gap between water demand and water availability by 2030, exacerbated by climate change.[xxxii] Achieving SDG targets on water, sanitation and hygiene (WASH) should be pursued in synergy with climate investments.

Paradigm shifts towards climate-resilient water management will require a range of actions across the whole water sector. These include ensuring water use efficiency and demand management; cross-sectoral water management at basin level with conjunctive use of rainwater, surface water and groundwater; as well as innovative financing and technology.[xxxiii] Substantial co-benefits can be realised through landscape approaches prioritising ecosystem integrity, as the retention of water in the landscape facilitates carbon capture and storage in soils and vegetation, as well as moderating temperatures and buffering against floods and droughts.[xxxiv]

GCF interventions in the water sector aim to promote IWRM, ensuring a synergistic approach to tackling the water-energy-food security nexus, and bridging between Integrated Adaptation and Transformative Resilience as set out in the introduction. Furthermore, GCF aims to stimulate private sector investment in water resources development and in water supply and sanitation, focusing particularly on less developed countries and the SIDS. GCF also supports the scaling-up of innovative technologies and financing models. All these actions need to take place within a stable governance system – fostered by the NAPs and sectoral plans - that provides an effective enabling environment for change to take place.

To ensure investments for systemic change, GCF can:

- Finance multi-purpose infrastructure that is climate-resilient and reduces disaster risk;
- Stimulate private sector participation by de-risking investment in water, using GCF guarantee instruments to bridge gaps in financing, supporting profitability of water sector projects; and
- Support disaster-risk insurance applications in the water sector.

To create an enabling environment for climate resilience in the water sector, GCF seeks to:

- Promote IWRM, building synergies to ensure water-energy-food security;
- Manage water demand via cost-reflective pricing, regulation and consumer awareness; and
- Promote national, basin and coastal zone planning, particularly in LDCs and SIDS.

Finally, GCF aims to leverage co-financing in the water sector by:

- Pursuing active partnerships with international finance institutions and multinational

corporations, to promote investment in water security;
- Scaling up innovative financing models and technologies by leveraging partnerships with national water and sanitation trust funds and the local private sector in developing countries; and
- Increasing advocacy for WASH, IWRM and coastal zone management by strengthening engagement with international water sector organisations.

Case study: South Tarawa Water Supply Project, Kiribati

Mitigation potential: 89,434 tonnes of CO_2 equivalent avoided
Beneficiaries: 62,298 beneficiaries increasing to 94,501 in 2041
Total financing: USD 58.1 million
GCF contribution: USD 28.6 million
Implementation period: 6 years

South Tarawa, the capital of Kiribati, is almost entirely dependent on underground freshwater lenses, the quality and quantity of which are seriously threatened by climate change-induced inundations, sea level rise and prolonged drought.

This project, co-financed by the Asian Development Bank and implemented by the Government of Kiribati, will reduce the climate vulnerability of the entire population of South Tarawa through increased water security by providing them with a reliable, safe and climate-resilient water supply. This will be achieved through the construction of a 4,000 m3 desalination plant, a solar photovoltaic system to provide low-emission power for the water supply network, and water supply network upgrades to reduce non-revenue water.

6.7. Climate-resilient infrastructure – an integrated approach to building transformative resilience

Resilient infrastructure is immediately required in many developing countries to protect citizens, assets and overall economies against climate change. Still, international community discussions on benchmarking solutions and financing remain fragmented. GCF is ready to help create climate-resilient infrastructure solutions, and to mobilize resources to co-finance transformative infrastructure investments in developing countries.

Climate change poses significant and increasing challenges for infrastructure, especially when it fails to account for climate risks and hazards. This often results in reduced asset lifetimes, higher capital expenditure and running costs, loss of income, and the increased risk of environmental damage in infrastructure projects. Furthermore, ill-planned infrastructure systems for transportation, energy or water can induce greenhouse gas emissions within their value chains, with long-term negative implications due to lock-ins.

At the same time, there is still room for improvement worldwide in benchmarking construction solutions against climate hazards and sharing successful examples. There is also a lot to be done to develop de-risking standards for private investors, to enhance their partnership in adapting infrastructure to the changing climate. Current private investment endeavours refer mainly to mitigation, focusing on renewable energy and to a lesser extent incorporating energy efficiency.

Developing climate-resilient infrastructure expertise needs to start with engineering solutions, construction codes and technical protocols. To create benchmarks, these endeavours will need to be proven in scale, as being resilient against a certain frequency and strength of climate hazards. The insurance industry also needs to complement these efforts as outlined in Section 5. In addition, technology transfer protocols will come into play, enabling developing countries to introduce new construction techniques.

Once sufficient technical expertise is gathered and tested, solutions on de-risking guidance can be advanced. Institutional and private investors, who develop and manage infrastructure assets, are invited to the GCF's community of stakeholders to join the effort of structuring de-risking methods. Fostering knowledge derived from the co-operation of a variety of experts including engineers, lawyers, project managers and financial specialists will lead to further de-risking. Underwriting tool-kits need to be created. Such financial facilitation will unlock investment in infrastructure to embrace adaptation elements.

Resource efficiency prescribes an integrated approach as the most desired option to climate-resilient infrastructure development. Whenever an infrastructure intervention is approached, it should comprise all the necessary climate provisions in the particular context, for example, against strong winds, flooding, and salt water intrusion in a coastal setting. Mutually-complementary advances in energy efficiency and the introduction of renewable energy sources should be combined to reduce future emissions.

While GCF has previously funded investments for climate-resilient infrastructure, further support and evolution is required to pursue a transformative resilience approach to infrastructure. Lessons can be learned from non-GCF infrastructure projects such as the reconstruction of the Slussen lock in Stockholm, which showcases elements of climate-resilient infrastructure. The New Slussen project focuses on redesigning and retrofitting the existing 80-year-old structure to address flood inundation around Lake Mälaren and saltwater intrusion resulting from sea level rise in the Baltic Sea. The new facility incorporates elements of climate

resilience and flexibility in its structure. It is one of the first projects based on Real Option Analysis, which is an analytical approach to investment decisions on energy, stocks, plant, and other factors that allows flexibility taking uncertainty into account. The project includes stronger foundations and lighter superior construction. This method allows the re-design of the upper part in several years' time, in accordance with future climate projections. The new Slussen facility will increase the lock's drainage capacity by widening and deepening its existing channels and will double the total discharge capacity of Lake Mälaren into the Baltic. At the same time, the new construction will also serve as a green, welcoming space for citizens, and this will be facilitated by the extensive re-design of transport modes in the area, including road and rail. Soft measures related to early warning systems will be incorporated to assure the most stringent safety measures and protocols.

As GCF continues to grow and learn from other projects, GCF will support further development of the climate-resilient approach to unlock the potential for infrastructure stocks, taking full account of climate risks as well as emissions impact. Infrastructure is especially prioritized in the project pipelines of the SIDS. GCF seeks to further its support to demonstration projects and programmes that work along the infrastructure value chain and build resilience through complementary initiatives with other sectors, rather than stand-alone interventions.

6.8. Resilient cities

The global population is projected to reach 9.8 billion by 2050, of which a large majority of people will live in urban areas.[xxxv] *There is a pressing need to ensure that urban sector investments, which will determine climate outcomes over centuries, are decoupled from economic growth of the cities and main population areas, and are low-carbon, energy efficient and thoroughly climate resilient.*

As cities and populations are some of the main drivers of anthropogenic climate change, addressing these issues requires fundamental system changes. GCF is seeking to support further action in areas with the greatest potential leverage effects for the urban transformation towards sustainability. Efforts to invest in climate-compatible cities may deliver impacts related to emission reductions from transport and waste, as well as buildings, urban systems, industries and appliances. They will also support adaptation by helping to strengthen the resilience of livelihoods of urban communities and will increase the resilience of urban infrastructure while reducing associated emissions. The urban transformation towards sustainability and resilience requires changes in land-use, waste management, energy and transport systems, industry and management of materials and material flows, urban settlement policies, and the resilient structural-spatial design of cities.

Demands on urban infrastructure development are significant: new homes and infrastructure will have to be built at a great speed for approximately 2.5 billion new city dwellers by the middle of the century, since the total urban population is projected to exceed 7 billion by 2050. About 85 percent of the demand for new housing is expected in emerging economies. [xxxvi] In countries that are already highly urbanized, there are needs to retrofit and upgrade existing infrastructure and to support efforts to strengthen urban systems. The great challenge will be to make the right decisions to ensure that urbanization takes the principles of climate resilience, sustainability and sustainable growth into account.

Resilience building is a key public policy tool. Weaker public institutions and the comparably poorer track record of public policy implementation means there is a need for systems-based approaches that build capacities in multiple sectors. The new threats and stresses from globalization, migration, and emergence of new technology mean that traditional and business-as-usual interventions will be limited to unlock full potential.

There is a need for a paradigm shift away from incremental approaches to infrastructure and urban development that are essentially driven by short term requirements, towards transformative changes with a strategic, long-term urban resilience. Tying urban resilience into the complex web of urban governance is key, but current governance trends show limitations in capturing resilience well. There is a lack of integration and long-term thinking; enabling environments vary in terms of how favourable they are to urban resilience building; countries provide very different contexts and position different actors at the forefront of governance; local governments are typically in the role of service provision whereas central or regional governments have greater capacities and resources; and the links between resilience and the mandatory enforcing, provisioning, incentivizing, and enabling functions of governance are complex.

The GCF pipeline shows that there is an increasing need for urban sector investments. GCF seeks to support development and improvement of transformative resilience approaches to support cities to consider mid-to-long term climate risks, and to provide a framework for creating integrated visions and platforms for de-risking. Working closely with national and local governments, promoting

access to finance and crowding-in private sector investments in the cities most ready to move from climate change planning to climate change action will unlock the potential for maximizing impacts.

Case study: Green Cities Facility

Mitigation potential: 11,923,000 tonnes of CO_2 equivalent avoided
Beneficiaries: 23,231,000 direct and indirect beneficiaries
Total financing: USD 604.1 million
GCF contribution: USD 98.98 million
Implementation period: 15 years

The Facility, proposed by the European Bank for Reconstruction and Development, is based on a country-driven and evidence-based approach that systematically prioritizes and then finances transformational municipal climate-related infrastructure investments. The Facility addresses multiple barriers to climate action in nine countries, including Albania, Armenia, FYR Macedonia, Georgia, Jordan, Moldova, Mongolia, Serbia and Tunisia. The project will deliver policy and strategy support to cities to assist them to prioritize actions; facilitate green city and resilient infrastructure investments; build capacity of key stakeholders; and provide a pathway for cities to access green finance and capital markets.

This systematic approach is based on a well-developed and tested methodology to develop a Green City Action Plan, which municipalities use to steer their own green urban planning initiatives and investments and to guide monitoring, reporting and further planning. The Facility's investments will focus on urban climate-resilient infrastructure in six sectors: low-carbon and climate resilient buildings, water and wastewater, solid waste, urban transport, district heating/cooling and street lighting. The Facility will therefore work with a range of stakeholders, from cities to national agencies, to develop the tools and skills that cities need to attract private sector finance for green investments, particularly in local capital markets.

The Facility will make available concessional financial instruments, which will be calibrated to address the incremental costs of low-carbon and climate-resilient infrastructure. Overall, GCF funding will allow the Facility to take on more ambitious investments, more effectively target innovative solutions in new market segments, and further incentivize market participants by reducing financing costs and risks.

7. Technology and innovation for accelerating adaptation

Technology and innovation are core to delivering the Paris Agreement and towards low-emission and climate-resilient development pathways. Technologies for adaptation require special consideration, and GCF is working with countries and partners across the technology cycle, from supporting research, development and demonstration to strengthening innovation systems.

GCF is mandated to support technology development and transfer in its support of the Paris Agreement, where technology and innovation are central features. In response to guidance from Conference of the Parties, GCF has reviewed options to support collaborative research, development and demonstration (RD&D) in developing countries, and emphasizes the importance of continued collaboration with the UNFCCC Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN) to strengthen cooperative action to implement GCF's support to climate technologies.

Countries' implementation of their NDCs is often conditioned, among other things, by limited access to technology. Providing support to mitigation and adaptation technologies are quite different in terms of their goals and their level of accessibility to financial support. Support for adaptation technology has been limited, although receiving increased attention. It requires a combination of both hardware and software recognizing the need to support development or improvement of innovation systems, processes, knowledge and skills required for using the technology. In Myanmar, for example, to address the national challenge in lack of access to data and information to assess and manage extreme flood and drought events, GCF has partnered with CTCN to strengthen science-based information availability and management in the country by implementing a vulnerability assessment and supporting the use of adaptation technologies.

Case study: Readiness Proposal with UNEP – CTCN for the Republic of the Union of Myanmar

The Readiness Proposal aims to strengthen drought and flood management through improved science-based information availability and management in Myanmar. This technical assistance seeks to facilitate transfer of technologies and improve information base for climate change adaptation decision-making, focusing on two key vulnerable sectors – agriculture and water resources. It is designed to enhance the capacity of relevant local government agencies to prevent and manage floods and droughts, through improved planning tools for building resilience to climate change.

GCF seeks to ensure that the activities it supports align with strategic national objectives and priorities and help advance ambitious action on adaptation in line with countries' needs. To better assist countries in formulating proposals for technology-related readiness programmes, GCF supports the identification of appropriate climate technology solutions, prioritized in accordance with national strategies and plans for climate adaptation and mitigation. GCF also supports the market preparation and business planning for deployment and scale-up of prioritized climate technology solutions. Levels of financing for different cycles of adaptation technologies need to be substantially increased, and public support is needed for RD&D and innovation, supporting areas of the technology cycle where private finance is absent. While there is still a lack of risk-tolerant and patient capital, as well as a broader range of public financing instruments that can unlock private sector investment, GCF's support can help close financing gaps through differential instruments for the deployment of adaptation technologies.

Case study: Climate Resilient Water Sector in Grenada (G-CREWS)

Beneficiaries: The whole population of Grenada (approx. 106,000 people, of whom about 50 % are of female)
Total financing: USD 48 million
GCF contribution: USD 40.3 million
Implementation period: 6 years

The project, supported by GIZ, aims to increase systemic climate change resilience in Grenada's water sector. The proposal seeks to promote paradigm shift to achieve resilient water demand and supply through behavioral change, appropriate governance, regulation, incentives and awareness raising, the participation of citizens and businesses in becoming more water-efficient, and the provision of sufficient and reliable water infrastructure.

Water and energy efficiency is also pursued by exploring and implementing solutions, including renewable energy technologies (e.g. solar powered water pumping, solar powered water treatment, hydropower micro turbines within the piped network) and support the water loss reduction technologies (e.g. efficient irrigation systems, rainwater harvesting, shadehouses and hydroponics for farms and efficient fittings and greywater recycling plant for hotels). The project has built-in components for potential for learning and replication in others parts of the Caribbean.

8. A Game-Changing Fund: GCF and the future of adaptation funding

Evidence from existing climate projects and their beneficial impacts upon people and communities highlight the need for policies, investments and systems in all sectors to become more adaptive and resilient to climate change. As climate effects accelerate, we all need to become increasingly attuned to how our actions affect the climate, and how we are affected by it. We are entering uncharted territory in terms of global temperatures and weather patterns. Our ability to adapt to new circumstances will be tested to the utmost, and adaptation is rapidly becoming the new imperative. Climate-related ways of thinking, seeing and acting will gradually need to become embedded within the very fabric of our society, as with all paradigm shifts. GCF is working with governments, private sector and communities across the world to build examples of green and climate-resilient realities and seeks, in the process, to be a truly game-changing fund.

As discussed in this paper, the central goal of GCF is to promote a paradigm shift towards climate-resilient development. This means embracing both adaptation (the ability to change in response to changing circumstances) and resilience (the ability to recover from disasters). We have seen how countries are already forging new development pathways by identifying climate risks and by developing long-term strategies and plans to guard against them. Adaptation is highly context-specific. Proposed adaptation solutions, though localized, require systemic change in order to have widespread impact. Solutions on the ground need to implement the vision set out in NAPs and strategies, and in turn those adaptation plans need to be informed by the evidence and learning from projects on the ground. In emphasizing the climate science behind adaptation projects, GCF ensures that adaptation and resilience projects build upon and complement the broader development efforts under way in developing countries.

The private sector has a transformative role to play in response to climate change, by helping economies and societies to adapt to the new and fast-changing environment. By enacting new laws and regulations and creating new institutions, governments can enable the private sector to play that role. In many instances, it is only the private sector that can devise the local climate products and climate solutions with the speed and flexibility needed. GCF is engaging more and more private sector actors in climate projects through private debt and equity, blended finance and a range of related instruments, for adaptation as well as mitigation projects. Identifying revenue streams from adaptation projects is the new frontier in adaptation financing. We have seen in Section 5 how the insurance and re-insurance industries are leading the way with new products and approaches such as forecast-based financing.

Integrated adaptation covers a diverse set of activities, from protecting people's health by issuing warnings and creating awareness of the dangers of heat waves, to transforming agriculture to cope with changing weather patterns, to protecting ecosystems to retain their functions as climate buffers. Integrated water resources management and forest-based adaptation are key to creating adaptive and long-lasting solutions to climate change. Resilient infrastructure and resilient cities will need increasing amounts of investment as the scale and extent of the climate risks of sea level rise, flash floods and storms become increasingly apparent to regional planners, local authorities and banks. It is crucial to ensure that transformative resilience is realized, by building back better after disasters, and by working with water, ecosystems and landscapes, rather than against them. Wherever possible, the mitigation co-benefits of adaptation projects also need to be maximized.

The brief sectoral discussions in this working paper will be further expanded and developed to produce a series of sectoral guidance documents over the next 18 months. GCF hopes to initiate fruitful discussions with stakeholders and continue to support ongoing adaptation project preparation activities.

Notes

[i] "Global Surface Temperature | NASA Global Climate Change," NASA, February 19, 2019, accessed March 23, 2019, https://climate.nasa.gov/vital-signs/global-temperature/.
[ii] "Climate Change: Vital Signs of the Planet," NASA, accessed March 23, 2019, https://climate.nasa.gov/.
[iii] Bette Hilleman, "Ice Core Record Extended: Analyses of Trapped Air Show Current CO 2 at Highest Level in 650,000 Years," *Chemical & Engineering News* 83, no. 48 (November 2005), http://pubs.acs.org/cen/news/83/i48/8348notw1.html.
[iv] IPCC, 2018: Summary for Policymakers, In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)], *World Meteorological Organization, Geneva, Switzerland,* 32 pp.
[v] Oxford English Dictionary, "Adaptation," Oxford Dictionaries | English, accessed March 23, 2019, https://en.oxforddictionaries.com/definition/adaptation.
[vi] UNFCCC, "What Do Adaptation to Climate Change and Climate Resilience Mean?" UNFCCC, accessed March 23, 2019, https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/what-do-adaptation-to-climate-change-and-climate-resilience-mean.
[vii] Oxford English Dictionary, "Resilience," Oxford Dictionaries | English, accessed March 23, 2019, https://en.oxforddictionaries.com/definition/resilience.
[viii] UNISDR, "2009 UNISDR Terminology on Disaster Risk Reduction," ISDR, 2009, accessed March 23, 2019, https://www.unisdr.org/we/inform/publications/7817.
[ix] "Tropical Cyclone Idai - Mar 2019," ReliefWeb, accessed March 22, 2019, https://reliefweb.int/disaster/tc-2019-000021-moz/thumb#content_top.
[x] IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
[xi] IPCC, 2018: Summary for Policymakers, In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)], *World Meteorological Organization, Geneva, Switzerland,* 32 pp.
[xii] *The Adaptation Finance Gap Report 2016*, report, UNEP, May 2016, accessed March 23, 2019, https://climateanalytics.org/publications/2016/the-adaptation-gap-report-2016/.
[xiii] Investor Group on Climate Change (IGCC), *From Risk to Return,* report, IGCC (2017), accessed March 23, 2019, https://igcc.org.au/risk-return-investing-climate-adapation-igcc-mar-2017/.
[xiv] IGCC, *From Risk to Return*.
[xv] The Geneva Association, *The Nature and Role of Capital in Insurance*, report, The Geneva Association (Zurich: 2016), accessed March 23, 2019, https://www.genevaassociation.org/research-topics/financial-stability-and-regulation/nature-and-role-capital-insurance.
[xvi] WHO, "Frequently Asked Questions," accessed March 23, 2019, https://www.who.int/about/who-we-are/frequently-asked-questions.
[xvii] WHO, "Climate Change and Health," February 1, 2018, accessed March 23, 2019, https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health.
[xviii] WHO, "Climate Change and Health," February 1, 2018, accessed March 23, 2019, https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health.
[xix] WHO, "Health Benefits Far Outweigh the Costs of Meeting Climate Change Goals," December 5, 2018, accessed March 23, 2019, https://www.who.int/news-room/detail/05-12-2018-health-benefits-far-outweigh-the-costs-of-meeting-climate-change-goals.
[xx] Rita Strohmaier et al., *The Agriculture Sectors in the Intended Nationally Determined Contributions: Analysis,* working paper no. 62, (Rome, 2016: FAO).
[xxi] Robert F. Townsend et al., *Implementing Agriculture for Development: World Bank Group Agriculture Action Plan (2013-2015) (English),* working paper no. 77911, (World Bank Group, 2013).
[xxii] Vincent Gitz et al., *Climate Change and Food Security: Risks and Responses*, report, (FAO, 2016).
[xxiii] FAO, WFP and IFAD, *The State of Food Insecurity in the World 2012. Economic Growth Is Necessary but Not*

Sufficient to Accelerate Reduction of Hunger and Malnutrition, report, (Rome: FAO, 2012).
[xxiv] FAO, *The state of food and agriculture 2016: climate change, agriculture and food security*, report, (Rome: FAO, 2016).
[xxv] FAO, "Forests and Poverty Reduction," FAO, May 15, 2015, , accessed March 23, 2019, http://www.fao.org/forestry/livelihoods/en/.
[xxvi] FAO, *The state of the world's forests: forest pathways to sustainable development,* report (Rome: FAO, 2018).
[xxvii] Millennium Ecosystem Assessment, *Ecosystems and human well-being: synthesis,* report, (Washington, DC: Island Press, 2005).
[xxviii] Gretchen C. Daily, *Natures Services: Societal Dependence on Natural Ecosystems,* (Washington, D.C.: Island Press, 1997).
[xxix] Robert Costanza et al., "The Value of the Worlds Ecosystem Services and Natural Capital," Nature 387, no. 6630 (1997): 253-60, doi:10.1038/387253a0.
[xxx] Johan Rockström, et al., "A Safe Operating Space for Humanity." Nature 461, no. 7263 (2009): 472–75, doi:10.1038/461472a.
[xxxi] UN-Water, "What is Water Security? Infographic", May 8, 2013, accessed March 23, 2019, http://www.unwater.org/publications/water-security-infographic.
[xxxii] Lisa Guppy and Kelsey Anderson, *Global Water Crisis: The Facts*, technical paper (Hamilton: United Nations University Institute for Water, Environment and Health (UNU-INWEH), 2017).
[xxxiii] UN-Water, *Climate Change Adaptation: The Pivotal Role of Water*, policy brief (UN-Water, 2010), accessed March 23, 2019, http://www.unwater.org/publications/climate-change-adaptation-pivotal-role-water/.
[xxxiv] William R. Moomaw et al., "Wetlands In a Changing Climate: Science, Policy and Management," *Wetlands* 38, no. 2 (2018): 183-205, doi:10.1007/s13157-018-1023-8.
[xxxv] UN, *World Urbanization Prospects The 2014 Revision*, report, Department of Economic and Social Affairs, UN (New York: UN, 2015).
[xxxvi] UN, *World Urbanization Prospects The 2014 Revision*.

Bibliography

Bhattacharya, Amar, Mattia Romani, and Nicholas Stern. *Infrastructure for Development: Meeting the Challenge.* Policy paper. Centre for Climate Change Economics and Policy, Grantham Research Institute on Climate Change and the Environment, 2012.

Costanza, Robert, Ralph Darge, Rudolf De Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert V. Oneill, Jose Paruelo, Robert G. Raskin, Paul Sutton, and Marjan Van Den Belt. "The Value of the Worlds Ecosystem Services and Natural Capital." Nature 387, no. 6630 (1997): 253-60. doi:10.1038/387253a0.

Daily, Gretchen C. *Natures Services: Societal Dependence on Natural Ecosystems*. Washington, D.C.: Island Press, 1997.

Erickson, Peter, and Kevin Tempest. *Advancing Climate Ambition: How City-scale Actions Can Contribute to Global Climate Goals*. Working paper no. 2014-06. Stockholm: Stockholm Environment Institute, 2014.

FAO. "Forests and Poverty Reduction." FAO. May 15, 2015. Accessed March 23, 2019. http://www.fao.org/forestry/livelihoods/en/.

FAO. *The state of food and agriculture: climate change, agriculture and food security*. Report. Rome: FAO, 2016.

FAO. *The state of the world's forests: forest pathways to sustainable development*. Report. FAO. Rome: FAO, 2018.

FAO, WFP and IFAD. *The State of Food Insecurity in the World 2012. Economic Growth Is Necessary but Not Sufficient to Accelerate Reduction of Hunger and Malnutrition.* Report. Rome: FAO, 2012.

Floater, Graham, Dan Dowling, Denise Chan, Matthew Ulterino, Juergen Braunstein, and Tim McMinn. *Financing the Urban Transition: Policymakers' Summary.* Policymakers' summary. London and Washington D.C.: Coalition for Urban Transitions, 2017.

Gitz, Vincent, Alexandre Meybeck, Leslie Lipper, Cassandra De Young, and Susan Braatz. *Climate Change and Food Security: Risks and Responses.* Report. FAO, 2016.

Guarnaschelli, Serena, Benhan Limketkai, Pauline Vandeputte, Lieke Homminga, Anisa Khadem Nwachuku, and Malika Mehta. *Financing Sustainable Land Use: Unlocking Business Opportunities in Sustainable Land Use with Blended Finance.* Report. KOIS Invest, 2018.

Guppy, Lisa, and Kelsey Anderson. *Global Water Crisis: The Facts*. Technical paper. Hamilton: United Nations University Institute for Water, Environment and Health (UNU-INWEH), 2017.

Hilleman, Bette. "Ice Core Record Extended: Analyses of Trapped Air Show Current CO 2 at Highest Level in 650,000 Years." *Chemical & Engineering News* 83, no. 48 (November 2005): 7. http://pubs.acs.org/cen/news/83/i48/8348notw1.html.

Investor Group on Climate Change (IGCC). *From Risk to Return.* Report. IGCC. March 2017. Accessed March 23, 2019. https://igcc.org.au/risk-return-investing-climate-adapation-igcc-mar-2017/.

Kraas, Frauke, et al. *Humanity on the move: Unlocking the transformative power of cities Flagship report.* Berlin: German Advisory Council on Global Change (WBGU), 2016.

Locatelli, Bruno; Evans, Vanessa; Wardell, Andrew; Andrade, Angela; Vignola, Raffaele. 2011. "Forests and Climate Change in Latin America: Linking Adaptation and Mitigation." *Forests* 2, no. 1: 431-450.

Maguire, Joe. "Global Infrastructure: How to Fill a $500 Billion Hole." *Credit Week* 34 (January 22, 2014): 12-19.

Mckinsey Center for Business and Environment. *A Strategic Approach to Climate Action in Cities—focused Acceleration*. Report. Mckinsey Center for Business and Environment, 2017.

Millennium Ecosystem Assessment. *Ecosystems and human well-being: synthesis*. Report. Millennium Ecosystem Assessment. Washington, DC: Island Press, 2005.

Moomaw, William R., G. L. Chmura, Gillian T. Davies, C. M. Finlayson, B. A. Middleton, Susan M. Natali, J. E. Perry, N. Roulet, and Ariana E. Sutton-Grier. "Wetlands In a Changing Climate: Science, Policy and Management." *Wetlands* 38, no. 2 (2018): 183-205. doi:10.1007/s13157-018-1023-8.

NASA. "Climate Change: Vital Signs of the Planet." Accessed March 29, 2019. https://climate.nasa.gov/.

Organisation for Economic Co-operation and Development (OECD). *Infrastructure to 2030.* Vol. 2. Paris: OECD, 2007.

Oxford Dictionaries. "Adaptation | Definition of Adaptation in English by Oxford Dictionaries." Oxford Dictionaries | English. Accessed March 29, 2019. https://en.oxforddictionaries.com/definition/adaptation.

PricewaterhouseCoopers LLP (PwC). *Capital project and infrastructure spending: Outlook to 2025*. PwC, 2017. Research by Oxford Economics

Rockström, Johan, Will Steffen, Kevin Noone, Åsa Persson, F. Stuart Chapin, Eric F. Lambin, Timothy M. Lenton, Marten Scheffer, Carl Folke, Hans Joachim Schellnhuber, Björn Nykvist, Cynthia A. De Wit, Terry Hughes, Sander Van Der Leeuw, Henning Rodhe, Sverker Sörlin, Peter K. Snyder, Robert Costanza, Uno Svedin, Malin Falkenmark, Louise Karlberg, Robert W. Corell, Victoria J. Fabry, James Hansen, Brian Walker, Diana Liverman, Katherine Richardson, Paul Crutzen, and Jonathan A. Foley. "A Safe Operating Space for Humanity." Nature 461, no. 7263 (2009): 472-75. doi:10.1038/461472a.

Strohmaier, Rita, Janie Rioux, Anika Seggel, Alexandre Meybeck, Martial Bernoux, Mirella Salvatore, Javier Miranda, and Astrid Agostini. *The Agriculture Sectors in the Intended Nationally Determined Contributions: Analysis*. Working paper no. 62. Rome, 2016: FAO.

The Geneva Association. *The Nature and Role of Capital in Insurance*. Report. The Geneva Association. Zurich: Geneva Association, 2016. Accessed March 23, 2019. https://www.genevaassociation.org/research-topics/financial-stability-and-regulation/nature-and-role-capital-insurance.

Tollin, Nicola, Johannes Hamhaber, Stelios Grafakos, Shuaib Lwasa, and Jordi Morato. *Sustainable Urbanization in the Paris Agreement: Comparative Review of Nationally Determined Contributions for Urban Content - Pre-release 2016 Comparative Review of Nationally Determined Contributions for Urban Content.* Nairobi: UN-Habitat, 2016.

Townsend, Robert F., Iride Ceccaccci, Sanjiva Cooke, Mark Constantine, and Gene Moses. *Implementing Agriculture for Development: World Bank Group Agriculture Action Plan (2013-2015) (English)*. Working paper no. 77911. World Bank Group, 2013.

WHO. "Climate Change and Health." February 1, 2018. Accessed March 29, 2019. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health.

WHO. "Frequently Asked Questions." Accessed March 23, 2019. https://www.who.int/about/who-we-are/frequently-asked-questions.

WHO. "Health Benefits Far Outweigh the Costs of Meeting Climate Change Goals." December 5, 2018. Accessed March 29, 2019. https://www.who.int/news-room/detail/05-12-2018-health-benefits-far-outweigh-the-costs-of-meeting-climate-change-goals.

UN, *World Urbanization Prospects The 2014 Revision.* Report. Department of Economic and Social Affairs, UN. New York: UN, 2015.

UNFCCC. "What Do Adaptation to Climate Change and Climate Resilience Mean?" Accessed March 29, 2019. https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/what-do-adaptation-to-climate-change-and-climate-resilience-mean.

UN-Water. *Climate Change Adaptation: The Pivotal Role of Water*. Policy brief. UN-Water, 2010. Accessed March 23, 2019. http://www.unwater.org/publications/climate-change-adaptation-pivotal-role-water/.

UN-Water. "What is Water Security? Infographic" May 8, 2013. Accessed March 23, 2019, http://www.unwater.org/publications/water-security-infographic.

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