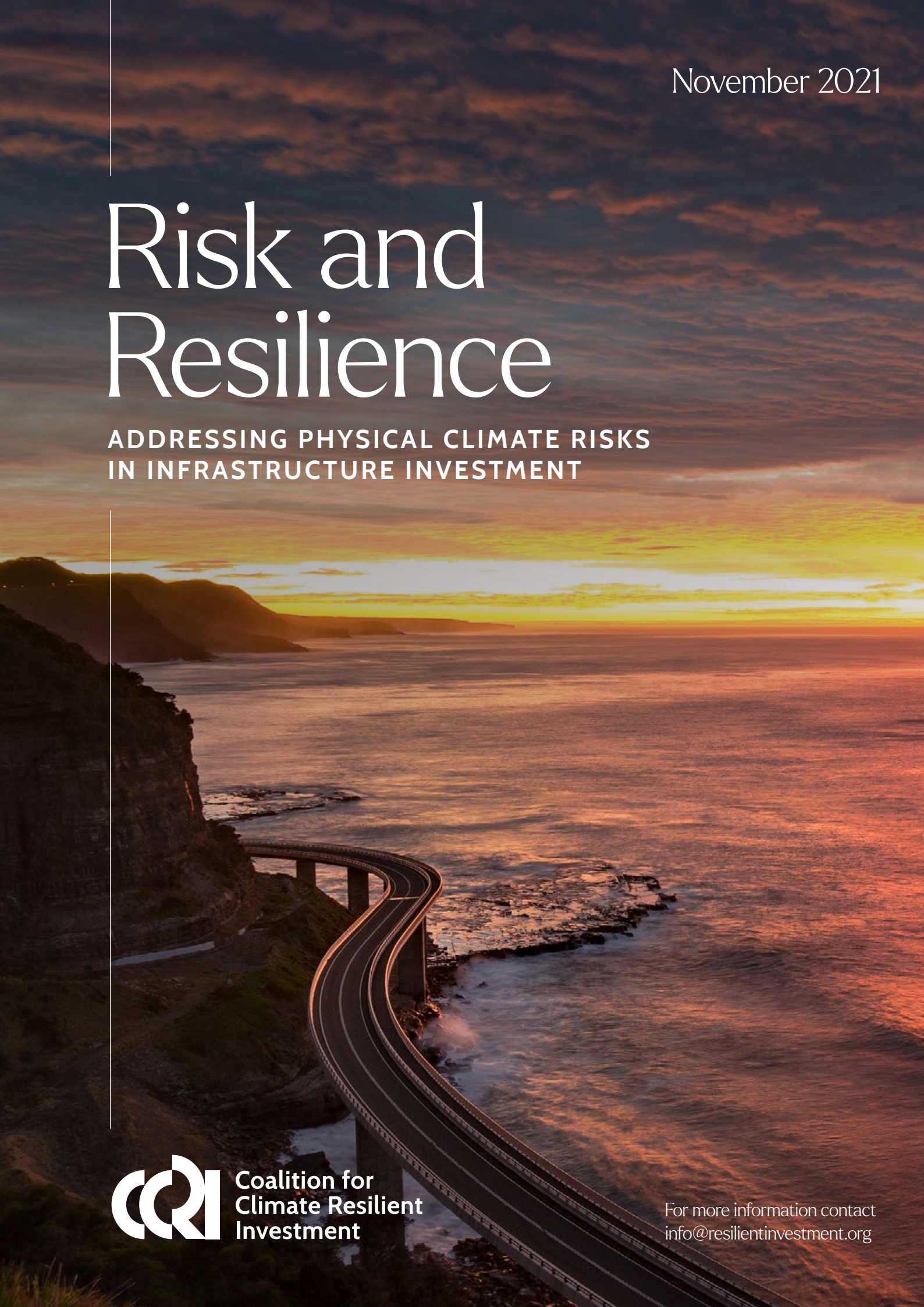
November 2021

Risk and Resilience

ADDRESSING PHYSICAL CLIMATE RISKS IN INFRASTRUCTURE INVESTMENT



Coalition for Climate Resilient Investment

For more information contact
info@resilientinvestment.org

H.E. ANTÓNIO GUTERRES

Secretary-General of the United Nations

"I am encouraged by the progress made by the Coalition for Climate Resilient Investment. Their efforts to develop practical solutions that better integrate and price physical climate risks in investment decision-making can make a difference. I have three priorities to make the world more resilient:

1. By 2025, use of systemic resilience tools, such as CCRI's national prioritisation tool, to be exponential and available to any developing country.

2. By the end of 2022, at least 25 developing countries to adopt CCRI's asset-level climate risk assessment methodology to support infrastructure investment decision-making.

3. To mobilise at least US$10bn from investors to secure capital for the League of Investment Funds for Resilience by the end of 2022.

CCRI's work advances all of these."

MARK CARNEY

UN Special Envoy for Climate Action and Finance, and the Finance Adviser to the UK Prime Minister for COP26, Vice Chair and Head of ESG and Impact Fund Investing at Brookfield Asset Management.

"The Coalition for Climate Resilient Investment's focus on integrating climate risks into decision-making will help finance the infrastructure investment needed to build an economy more resilient to climate change."

CONTENTS

FOREWORDS 6

A LETTER FROM OUR ACADEMIC CO-CHAIRS 10

EXECUTIVE SUMMARY 12

INTRODUCTION TO CCRI 16
Background 17
Purpose 18
Activities and Deliverables 19

THE CASE FOR RESILIENCE BUILDING 20
Overcoming 'Market Failure' 22
The 'Resilience Gap' 23
Climate Resilient Infrastructure 24

CCRI FRAMEWORK 28
1. SYSTEMIC RESILIENCE 30
Case Study: Jamaica 32

2. ASSET DESIGN, STRUCTURE AND VALUATION 34
ADS Framework 36
Physical Climate Risk Assessment Methodology 37
Principles for the inclusion of PCRs in infrastructure investment appraisal 39
Climate resilience credit quality drivers 39

3. FINANCIAL INNOVATION 40
Solving the valuation conundrum by decoupling time and risk 41

COLLABORATION 42

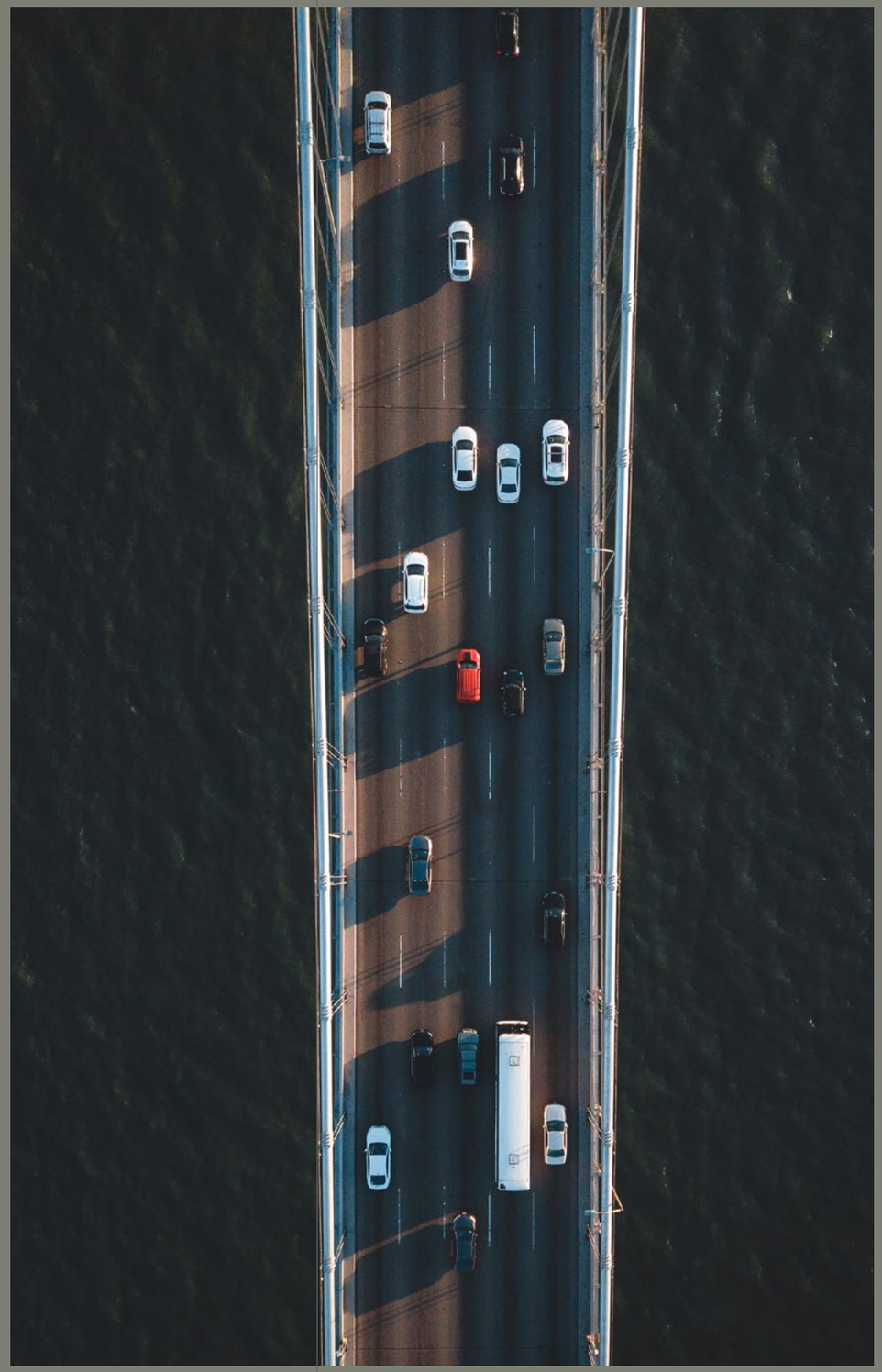
NEXT STEPS 50

CONCLUDING REMARKS FROM THE EXECUTIVE DIRECTOR, CCRI 53

REFERENCES 54

This paper focuses on the need to incorporate physical climate risks in infrastructure design and investment decision-making.

It presents how the Coalition for Climate Resilient Investment (CCRI) is addressing the 'climate resilience market failure' through the implementation of tools, methodologies and principles to help the various stakeholders involved in infrastructure, including the financial industry, build resilience to a changing climate.



ACKNOWLEDGEMENTS

CCRI is extremely grateful to its advisors, contributors and reviewers for their support on this paper. It was made possible thanks to the generosity and wisdom of many people who made time to speak, write, proof the report and offer comments to the team. The following individuals and organisations deserve a special mention for their contributions and for their significant inputs and time commitment in support of CCRI activities:

CO-AUTHORS

Lucy Carmody: Advisor to CCRI
Alexandre Chavarot: Advisor to CCRI

CONTRIBUTING EDITORS

Gaia De Battista: Executive Director, Lion's Head

Murray Birt: Senior ESG Strategist, DWS

Chris Canavan PhD: Partner, Lion's Head

Chris Dodwell: Head of Policy and Advocacy, Impax Asset Management

David Espinoza PhD: Senior Principal, Geosyntec Consultants

Nisha Krishnan PhD: Senior Climate Finance Associate, World Resources Institute

Gianluca Minella: Head of Infrastructure Research, DWS

Carlos Sanchez: Executive Director, CCRI

Gireesh Shrimali PhD: Precourt Energy Scholar, Stanford University

Alan Smith: Senior Advisor, ESG Risk and Inclusion, HSBC

ACADEMIC CONTRIBUTORS

Professor Charlie Donovan: University of Washington, Imperial College London

Professor Uli Hege: Toulouse School of Economics

CONTRIBUTORS

CCRI: Margarete Ciuk, Andy Collis, Shazre Quamber-Hill

Mott McDonald: Dominika Nowosinska, William Phillips, Nikki van Dijk

S&P Global Ratings: Paul Munday, Michael Wilkins, Luisina Berberian

S&P Market Intelligence: Irina Neustroeva

We are also grateful to the numerous public sector officials who shared their expertise and advice, including representatives from the Foreign, Commonwealth & Development Office, and the COP26 UN Climate Change Conference Presidency.

Introduction from the Co-Chairs of CCRI

SAMIR ASSAF

Co-Chair, CCRI

Chairman, HSBC Corporate and Institutional Banking

Chairman, HSBC Corporate and Institutional Banking and Chairman of the Board for HSBC Middle East, with a focus on sustainable finance and developing partnership opportunities. Samir serves as co-Chair for the Coalition for Climate Resilient Investment and represents HSBC across initiatives including FAST-Infra, OnePlanet and The Prince of Wales Accounting for Sustainability Project Summit amongst others.

"Extreme weather events are becoming the norm, placing countries and communities across the world at ever increasing risk. It is crucial that we respond by adapting to the new normal and that the private sector, governments, international organisations and other stakeholders – all brought together by CCRI – continue working together to accelerate the shift towards greater resilience".

JOHN HALEY

Co-Chair, CCRI

CEO, Willis Towers Watson

Chief Executive Officer and a Director of Willis Towers Watson. Board member of Maximus, Inc., the Miami Cancer Institute, and the New World Symphony. A Fellow of the Society of Actuaries and the Conference of Consulting Actuaries, previous trustee of The Actuarial Foundation, and a co-author of Fundamentals of Private Pensions (University of Pennsylvania Press).

"The warming we've experienced to date has made changes to many of our planetary support systems irreversible on timescales of centuries to millennia. With extreme weather taking hold in every part of the world, CCRI is making incredible progress to advance practical solutions that support an orderly transition to a low-carbon, resilient economy and make sure the world is able to adapt swiftly, effectively and collaboratively to our changing world."

EMMA HOWARD BOYD

Co-Chair, CCRI

Chair, Environment Agency England

Chair of UK Environment Agency, Ex-officio board member, Department for Environment, Food & Rural Affairs, Advisor to the UK Board of Trade. Also serves on the Boards of The Prince of Wales Accounting for Sustainability Project Summit, the Green Finance Institute, Coalition for Climate Resilient Investment, Centre for Greening Finance and Investment, Council for Sustainable Business, European Climate Foundation, and Menhaden plc.

"The Intergovernmental Panel on Climate Change recently said global surface temperature will continue to increase until at least the mid-century, even in the best case scenarios. People need to be ready for at least 30 years of floods, heatwaves and sea level rises. By including physical risks in upfront financial decisions, members of CCRI – with over $20 trillion in assets – aim to incentivise a shift towards greater resilience."

Our Members

INSTITUTIONAL INVESTORS

Aberdeen Standard Investments
AVIVA INVESTORS
Invesco
AustralianSuper
aware
CALSTRS
B CAPITAL PARTNERS
CBRE GLOBAL INVESTORS
CLIMATE FUND MANAGERS
DWS
DENHAM CAPITAL
NEPHILA
Environment Agency
Fidelity INTERNATIONAL
LION'S HEAD global partners
IMPAX Asset Management
The Lightsmith Group
Legal & General INVESTMENT MANAGEMENT
Green Investment Group
meridiam
sura ASSET MANAGEMENT
ODDO BHF
Schroders
futurefund
Willis Towers Watson

LENDING INSTITUTIONS

WELLS FARGO
HSBC
Standard Chartered
LLOYDS BANKING GROUP

CREDIT RATING

Moody's
Trucost ESG Analysis S&P Global

FINANCIAL DATA

AGVESTO
OCTOBRE
REFINITIV

CLIMATE RISK DATA

AIR A Verisk Business
JUPITER Predicting risk in a changing climate
TRUCOST
lobelia. Turning data into useful information
one concern
XDI CROSS DEPENDENCY INITIATIVE

INSURANCE

PRUDENTIAL
NEPHILA
Munich RE
THE GENEVA ASSOCIATION INSURANCE FOR A BETTER WORLD
ZURICH
TOKIO MARINE
IBC BAC Insurance Bureau of Canada / Bureau d'assurance du Canada

CONSTRUCTION/ENGINEERING

AECOM
nationalgrid
HIGH SPEED
MOTT MACDONALD
ARUP
RESALLIENCE
ATKINS
Geosyntec consultants
anglianwater
WSP
DMEC DUTCH MARINE ENERGY CENTRE
VINCI

LEGAL

CLYDE&CO

STANDARDS

Climate Bonds Initiative
GRESB

GOVERNMENTS

MULTILATERAL INSTITUTIONS

WORLD BANK GROUP
European Bank for Reconstruction and Development
GREEN CLIMATE FUND
ADB ASIAN DEVELOPMENT BANK
European Investment Bank
Global Infrastructure Facility
IDB Inter-American Development Bank

PUBLIC INSTITUTIONS/THINK TANKS

A4S ACCOUNTING FOR SUSTAINABILITY
GARI
Adrienne Arsht-Rockefeller Foundation Resilience Center
Investor Group on Climate Change
GLOBAL CENTER ON ADAPTATION
CGFI UK Centre for Greening Finance & Investment
fsdafrica
ASIA INVESTOR GROUP ON CLIMATE CHANGE An AsriA Initiative
Global Water Partnership
IIGCC The Institutional Investors Group on Climate Change
#NSFM NextGen
WORLD RESOURCES INSTITUTE
E3G
TCFD TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES
Global Infrastructure Hub
SYSTEMIQ
THE RESILIENCE SHIFT
Green Finance Institute
Foreign & Commonwealth Office
Department for Business, Energy & Industrial Strategy
CLIMATE POLICY INITIATIVE

ACADEMIC/RESEARCH

EDHEC infra
UNIVERSITY OF OXFORD
Imperial College London
Toulouse School of Economics

INTERNATIONAL ORGANISATIONS

OECD
Food and Agriculture Organization of the United Nations
UNDP
UNITED NATIONS
FINANCE UNEP INITIATIVE

CONVENING PARTNERS

WORLD ECONOMIC FORUM
UN CLIMATE CHANGE CONFERENCE UK 2021
GLOBAL CENTER ON ADAPTATION
WORLD RESOURCES INSTITUTE

CONSULTING/AUDITING

ACCESS CORPORATE FINANCE
accenture
GOIMPACT CAPITAL PARTNERS 思博资本
OXFORD ECONOMICS
cambridge econometrics clarity from complexity
CLIMATE KIC AUSTRALIA
McKinsey & Company
KPMG

Members as of October 2021

Letter from our Academic Co-Chairs

Climate change makes a fundamentally unknowable future even more uncertain. Climate risks are hard to estimate because future outcomes directly depend on our efforts to mitigate and adapt. The divide between public interest and private ownership doesn't make it any easier. Even once it is clear what investments need to be made, which should be done by public entities, and which are best left to the private sector?

The key question for the private sector is how to make sound investment decisions amidst the uncertainties of geophysical, economic and political changes. Translating the complexities of climate change into indicators of financial risk poses many problems. How should new economic scenarios be constructed and how should they be adjusted to reflect local conditions? How should analysts account for different levels of climate risk sensitivity? How should we deal with a "tragedy of the horizon" embedded in nearly all models of financial decision-making?

Finance academics and capital markets practitioners around the world continue to struggle in making dollars and cents out of climate risks. We know that fundamental tasks such as calculating investment hurdle rate or estimating future cash flows and returns should be conditioned by climate financial risks. But the question remains, how?

While there are many areas of consensus about climate change, broad agreement about new corporate financial practices is not one of them. Climate finance remains a nascent field and the list of tasks ahead to improve practice remains long. Investment analysts need to know where in the decision-making process climate risks should be introduced. They need to know how new risk variables should be calculated, or whether traditional variables should be modified. They need to know what data is deemed to be reliable. And they'll need to draw on some form of consensus about the tools and methods of climate risk modelling. All told, it's a big agenda.

Many voices have called for mainstream academic finance to move faster in addressing climate change. Fortunately, it appears that the dam of resistance is now breaking. Climate finance has become an active subfield of academic research. But to really thrive, it needs new partnerships.

Much of modern finance theory is built on foundations that are more than half a century old. It's not obvious how existing frameworks should be adapted. Technology offers some hope, with advances in computing and artificial intelligence leading to enormous strides in the way that finance is researched and practiced. This should be particularly useful to integrating climate risks. But the power of computational methods is not enough. We also need conceptual advances.

THREE BASIC STEPS will prove critical in fostering the integration of climate risk in financial decision-making. The **FIRST is to harness the power of science and technology to generate new data. SECOND, that data needs to be standardised and pulled into new methodological tools. THIRD, new approaches to corporate finance and investment analysis will need to be disseminated into the mainstream.** These sequential tasks are well embedded in the aims of the Coalition for Climate Resilient Investment.

It has been our great pleasure to serve as academic co-chairs of this important initiative. There is much work to be done by both academics and practitioners to create new conceptual foundations for climate financial risk. Colleagues around the world are taking up the challenge in core fields such as strategic asset allocation, asset valuation, and risk management. Climate risk in financial decisions increasingly features in how we teach. Yet we are, in many ways, still at the starting point.

Climate change and natural capital are not external to economic activity, they are part and parcel of it. All our livelihoods depend upon a living and healthy planet. We hope this report will be an important marker in an ongoing process to improve both mental and computational models. Financial decision-makers can no longer ignore climate risks and other environmental challenges. This report is a crucial contribution to our state of knowledge about the new bottom line for business.

CHARLIE DONOVAN, Visiting Professor of Finance, University of Washington; Honorary Fellow, Imperial College London

ULRICH HEGE, Professor of Toulouse School of Economics

Executive Summary

"Current investment into resilience is comparatively low due to a lack of analytical tools to quantify the exposure of a 'real asset' to physical climate risks ("PCRs"); the difficulty in determining and comparing resilience options: and the fact that investors don't currently adjust their expected returns or cost of capital to account for such risks. This situation, de facto, corresponds to a market failure."

Climate change poses a systemic risk to society, the economy and financial markets. Climate hazards are directly responsible for the destruction of forests and productive agricultural land as well as vulnerable coastal communities and urban infrastructure. The global economy is set to lose up to 18% of GDP by 2050 due to climate change if no mitigating action is taken (resulting in a 3.2 °C temperature increase over preindustrial levels).[1] These hazards affect the smooth running of the global economy and add a new category of risks for investors and lenders. Mark Carney announced in 2015 that climate change was a systemic risk to financial markets and that the speed at which the associated re-pricing of physical, transition and liability risks occurs "could be decisive for financial stability".

The impacts of climate change are real and, due to atmospheric physics, will become more harmful and unpredictable, even if we were to ban all use of fossil fuel today. Recent droughts in Zimbabwe, wildfires in California and Canada, and floods in Germany, Kenya and India show us, in differing ways, what awaits us all if action is not taken to adapt effectively to our changing world. We need a colossal and rapid mobilisation of investment capital to find solutions which will both mitigate climate change and increase our resilience to it.

New paradigms for action on mitigation, such as 'Net Zero' objectives, and investment in mitigation solutions is increasing, yet current investment into resilience is comparatively low, with around US$35.4bn in global adaptation finance in 2018.[2] This can be explained by a number of factors, including a lack of analytical tools to quantify the exposure of a 'real asset' to physical climate risks ("PCRs"); the difficulty in determining and comparing resilience option: and the fact that investors don't currently adjust their expected returns or cost of capital to account for such risks. This situation, de facto, corresponds to a market failure.

The main consequence of this failure is that incorporating long-term resilience to PCRs into new or existing physical assets is currently not explicitly rewarded by the equity, credit or insurance markets. Current investment appraisal frameworks do not consider these risks and are not properly structured to assess the range of exposure of a real asset to PCRs, let alone identify ways to reduce such exposure.

Investors, particularly institutional investors such as pension funds and insurance companies, are understandably keen to integrate PCRs into their investment appraisals. They are also interested in the potential repricing of investments brought about by an enhanced understanding of resilience, as well as new investment opportunities in resilience. They expect the long-term risk and return profiles of financial portfolios to improve through the incorporation of these risks into the investment process. Investors are increasingly relying on the improving availability and quality of climate data – but more needs to be done.

The **Coalition for Climate Resilient Investment** ("CCRI") aims to be part of the solution. It was launched at the General Assembly of the UN in 2019 as a private sector-led initiative to address the market failure referred to above and help mobilise investment in climate resilience. **CCRI is committed to building resilience in a changing climate by promoting the efficient integration of PCRs in investment decision-making, ensuring all deliverables are in the public domain**. The initiative is central to the UK Government's COP26 Strategy for Adaptation and Resilience.

CCRI has set up three working groups to implement its mission and achieve its current objectives. These aim to address systemic resilience at the national level, ensure PCRs are included in the design, structuring and valuation of infrastructure assets; and to support the development of financial innovations to facilitate the flow of capital towards resilient investments.

CCRI recently launched a **Systemic Resilience Forum** which focuses on the delivery of a dynamic representation of exposure within a particular infrastructure system or geography to a defined set of climate hazards. The Forum is working towards the development of an infrastructure prioritisation tool and a set of PCR metrics.

The **Asset Design and Structuring** working group has been preparing a **'Physical Climate Risk Assessment Methodology'** for asset managers and a set of Principles for the inclusion of PCRs in investment appraisal. A credit quality simulation report linked to the case studies is being developed, the **'CCRI's S&P Resilience Credit Quality Drivers'.**

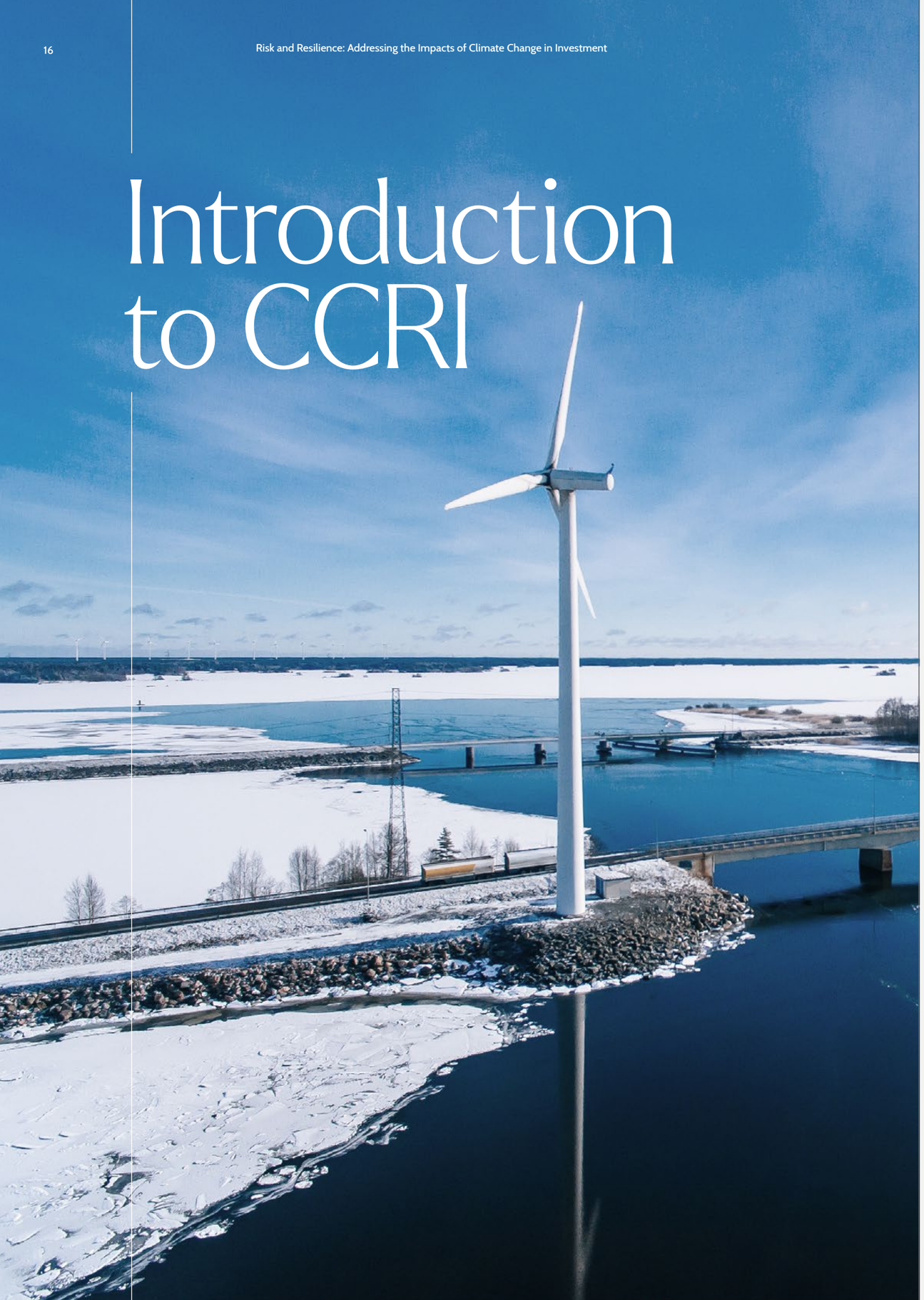
Separately, CCRI has been working with different capital markets and insurance practitioners through its **Financial Innovation** working group to design pilot transactions that fund resilience investments in infrastructure assets and incentivise the efficient pricing of PCRs. The use of parametric insurance solutions is being considered to address bankability issues linked to asset PCR exposure.

CCRI activities complement the many other initiatives, regulatory frameworks and existing analytical frameworks in development. The deliverables we have been working on are intended to support key regulatory and analytical initiatives by providing a 'proof of concept' of efficient pricing of PCRs. Organisations in this area present progress to the Executive Office of the UN Secretary General as the network of partnerships and collaborations grows, to avoid duplication and redundancy.

As a COP26 adaptation, resilience and finance initiative, CCRI has developed, in coordination with the COP26 Presidency, a programme comprised of several finance-related panel sessions on resilience, alongside an art exhibition, 'Art + Resilience'. The proposed panel events, aligned with CCRI's three working groups, will be held during the Adaptation and Finance days at COP. CCRI is also exploring further sessions in partnership with individual countries to be hosted within their Pavilions.

Beyond COP26, CCRI will focus on the practical implementation of its methodology, analytical tools and proposed principles in the infrastructure sector. It will also consider expanding its activities to other asset classes, such that all investment and lending decisions eventually incorporate chronic and acute physical climate risks and consider climate resilience.

Introduction to CCRI



Background

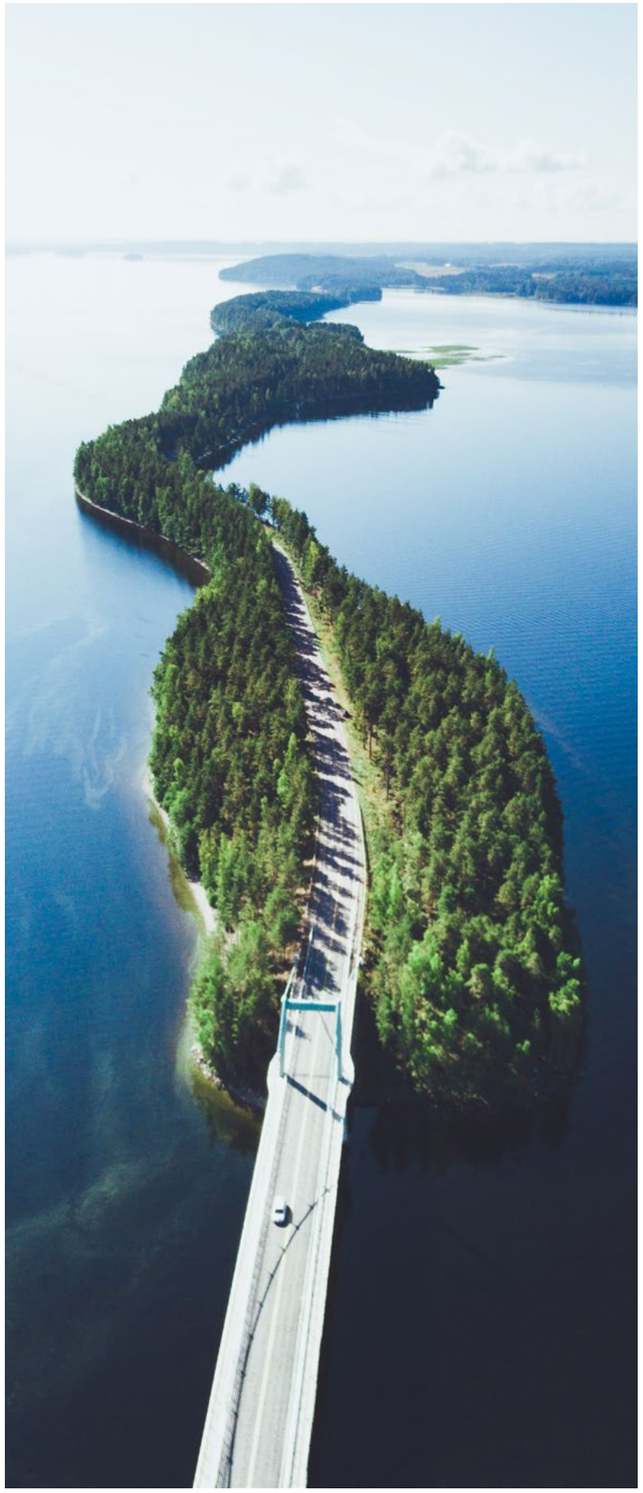
The Coalition for Climate Resilient Investment is a broad-based, global coalition which aims to 'mainstream' climate risks in investment decision-making. It was launched formally at the UN Climate Action Summit in 2019 with the UK Government, the World Economic Forum and Willis Towers Watson spearheading the initiative. The other convening institutions include the Global Commission on Adaptation and the World Resources Institute.

The Co-Chairs of CCRI are the UK Environment Agency, HSBC and Willis Towers Watson, who provide the secretariat. The three CCRI Co-Chairs, Emma Howard Boyd (Chair of the Environment Agency, United Kingdom), Samir Assaf (Chairman, Corporate and Institutional Banking, HSBC) and John Haley (CEO, Willis Towers Watson), function as a CCRI Steering Committee until COP26 in November 2021.

An Operating Committee provides guidance to the Executive Team and meets every other week. It includes representatives from UK Government, the World Economic Forum, the Global Commission on Adaptation, the World Resources Institute and experts in climate and development finance. The CCRI Executive Team is led by Carlos Sánchez, also Director of Climate Resilience Investment at Willis Towers Watson. He is supported by Courtnae Bailey (Programme Coordinator), Alexandre Chavarot (Strategic Financial Advisor to CCRI), Margarete Ciuk (Head of Operations) and Shazre Quamber-Hill (Programmes and Partnerships Lead). Representatives from CCRI member financial institutions are invited to attend our annual CCRI Leaders Roundtables.

Since launch, over 120 institutions have joined CCRI, covering the entire financial and physical infrastructure ecosystem and including international convening partners and organisations, governments, multilaterals, non-profits, think tanks and academics, institutional investors, asset managers, pension funds, banks, insurers, standard setters, ratings agencies, lawyers, engineers and developers, consultants, auditors and financial and climate data providers. Financial sector participants represent over US$20tn of assets. Membership of the Coalition is free.

Activities and contributions are tailored to the expertise, commitment and capacity each organisation can offer. Opportunities include contributions to working groups, provision of case studies, support with the implementation of CCRI outputs and broader support to CCRI and its goals such as representation at events and conferences. In 2021 the work being led by CCRI received recognition from both the G7 Foreign and Development Ministers and Insurance ERM, who awarded CCRI Climate Risk Initiative of the Year 2021.



Purpose

The Mandate

The mandate of CCRI is to address the market failure arising from the current global mispricing of physical climate risks in investment decision-making. To advance our mandate, member institutions, representing all relevant sectors and disciplines collaborate to deliver open-source CCRI solutions which can be used by all.

Our Vision

Our vision is a global financial industry and system in which key incentive structures, cost of capital and regulation efficiently promote the adequate integration of physical climate risks in investment decision-making, building resilience to a changing climate.

Our Mission

Our mission is to mobilise private finance, in partnership with key public institutions, to develop and implement practical solutions for the effective integration of PCRs and the acceleration of investments flows in climate resilience.

Activities & Deliverables

CCRI focuses on building knowledge, resources and capacity which can be used in various locations to encourage the enhanced resilience of infrastructure to physical climate risks.

CCRI has developed a framework for approaching the different levels of physical climate risk within the global economy. These go from the top-down, looking at **systemic risk and resilience**, to the bottom-up, looking at how investors should integrate physical climate risk considerations in the **asset design and structuring** of specific investments. A third workstream focuses on the **financial innovation** required to achieve the objective that all investments must consider and integrate physical climate risks.

These workstreams are steered by the Executive Team and members are encouraged to actively participate where they can add value. There is a flow of learning both within and between the groups and from the groups to the outside world, through the strategic communications of CCRI. We are working with local and national governments, asset owners and operators, investors and their advisers on several specific case studies to develop a set of tools and guidelines that can be applied more broadly.

CCRI focuses on building knowledge, resources and capacity which can be used in various locations to encourage the enhanced resilience of infrastructure to physical climate risks. We do this through building alliances with our members, their partners and leading initiatives in this area, such as the Coalition for Disaster Resilient Infrastructure (CDRI).

The 2021 deliverables of CCRI include

- **Systemic Resilience:** Improving government prioritisation of national resilience infrastructure and developing a metric for systemic resilience;
- **Asset Design & Structuring:** Developing frameworks for the integration of physical climate risks in investment appraisal; and
- **Financial Innovation:** Advancing innovative financial instruments to attract more capital to resilient investments.

Longer term, CCRI is looking to expand its role across several asset classes. Ultimately, CCRI envisions being an institution that serves as a catalyst towards the mobilisation of financial resources to improve the resilience of assets to physical climate risks. It will continue to disseminate a series of tools and methodologies that should facilitate the translation of physical climate risks into financial decision-making.

The Case for Resilience Building

The world's attention has been largely focused on reducing greenhouse gas (GHG) emissions and finding low-carbon solutions to replace our current reliance on fossil fuel.

Even if we are successful on all mitigation fronts, and achieve our Net Zero targets, our physical world will continue to be affected by the consequences of two centuries of GHG emissions and associated global warming and changing climate. In other words, even if we get to Net Zero, we need to build in resilience now. Adaptation and mitigation need to be done in tandem as they are mutually reinforcing.

CCRI exists to sound a clarion call to highlight the importance of enhancing asset resilience to PCRs to reduce the consequences of climate change on society. Climate change threatens to damage economic systems and destroy vital infrastructure assets, posing perils that reveal the vulnerabilities of both our built and natural assets.
The financial system addresses physical climate risks to real assets either by making infrastructure more resilient, so it better withstands chronic changes and climatic extremes, by 'mutualising' the risks and offsetting them in the financial and insurance markets, or by doing both. It is important that practitioners and investors understand that, due to the scale of the issue, and the limitations of the insurance industry to absorb losses from ever more extreme climate events, our priority should be adaptation and resilience building. Mutualisation should be considered when resilience options have been explored and incorporated. Both approaches are vital components of a more resilient future which complement each other.

"Our Fundamental Resilience Challenge"

ROWAN DOUGLAS, CBE
Head of the Climate and Resilience Hub, Willis Towers Watson

"A global data emergency is driving this climate resilience emergency. Leading investors are hungry to integrate physical climate risks (PCRs) into decision-making and valuation. At present they cannot, due to the lack of consistent data and agreed methodologies. Left unresolved, this gap means millions of lives and livelihoods, and billions in assets and development gains, will be lost in the years and decades ahead.

This is our fundamental resilience challenge.

CCRI is solving this growing human and financial crisis by pioneering the methods, metrics and models that turn climate physics into cashflows and resilience into risk-adjusted returns.
We are retooling the invisible hand of economics to deliver climate resilience for communities, companies and countries.

This process has come so far, so quickly because we all - the investors, the engineers, the reinsurers and credit analysts, the climate modellers and actuaries - **have the ingredients and the expertise.** We just needed a new recipe to bring it together. CCRI is providing this, along with a sophisticated new set of tools, and a new, shared mission, to 'bake-in' resilience to climate change."

Overcoming 'Market Failure'

CCRI adopts the premise that the perils associated with climate change are insufficiently incorporated into investment decisions, especially those having to do with infrastructure. There is incontrovertible evidence of a looming climate crisis that will lead to higher sea levels, droughts, violent storms and flooding. These severe climatological phenomena pose considerable risks to physical infrastructure. Yet investors have changed very little about how they plan, design and finance large-scale infrastructure when it comes to climate resilience. If the tools of finance are as forward-looking and sophisticated as we presume, we should have seen, by now, significant changes in how infrastructure investment decisions are made. Market actors are not always rationally processing the evidence of impending PCRs as we would expect them to.

This is an obvious case of market failure. We need markets to mobilise the hundreds of billions of dollars of climate-resilient investment required yet we lack an agreed consistent method of incorporating acute and chronic PCRs, resulting in markets that may be insufficiently developed with regard to climate resilience, and therefore not facilitating the flows. This question frames our work: why have markets failed and what can CCRI and its partners do to address the situation?

Markets fail for a variety of reasons. In the case of climate change, the most common form of market failure arises because of so-called negative externalities – adverse consequences from economic activity (like the production of carbon-based energy) whose environmental and social costs are not sufficiently borne by private actors. Aligning private and social interests may require a combination of taxes, regulations and financial incentives.

Sometimes there is insufficient or poor quality data available to support healthy markets (which are, after all, mechanisms in which savers, investors, buyers and sellers exchange information about value). Despite how much we already know about climate change and its consequences, more information would help. In other instances markets fail because of a lack of analytical tools for investors to convert raw data into information that is relevant to investment decisions. This is inevitably a challenge in the face of climate change.

Part of the work of CCRI is to identify the tools needed to harness information about climate to inform investment decisions; and to analyse how financial instruments and market mechanisms could help market players, including governments and regulatory authorities, interact more productively. We use the concept of market failure to frame this work. It is a framing that focuses primarily on markets and private actors, such as institutional investors. It also appropriately accommodates the public sector, demonstrating how well-designed regulation, taxation and other forms of state intervention can help markets operate properly. It requires us to pay attention to every dimension of what makes markets work well: the availability of raw information, the analytical tools required, the legal and regulatory frameworks of market activity, and the complicated ways in which market players interact with each other.

We believe that this broad and comprehensive approach is what is needed to achieve our goal of ensuring all infrastructure investments are climate-resilient.

We have, therefore, developed an immediate approach to overcome the market failures we observe, which, for now focuses exclusively on:

- Developing key solutions and analytics for the infrastructure asset class;
- Encouraging the pricing and management of physical climate risk in infrastructure investment; and
- Ensuring deliverables align with the needs and characteristics of investors and public policy-makers.

The 'Resilience Gap'

Resilient infrastructure is essential for global well-being, quality of life, and economic prospects. Populations require stable, safe and operational power facilities, transport links, workplaces, schools, and hospitals for societies to function efficiently. With the expected growth in global population, the Global Infrastructure Hub estimates that USD94tn is needed for infrastructure investment by the early 2040s[3] to sustain economic growth and address vulnerabilities of existing assets, and that annual infrastructure spending needs to rise to 3.5% of global GDP from the current 3%, or 3.7% if we are to meet the UN Sustainable Development Goals by 2030. Separately, a 2017 OECD study calculated investment needs of USD6.3tn annually to 2030 to meet the UN Sustainable Development Goals and almost USD7tn to meet the Paris Agreement Goals on reducing emissions[4]. The gap over current spending is thought to be up to USD3tn per annum.

Investment in climate resilient infrastructure in vulnerable developing countries is particularly important as it will help address both their exposure to chronic and acute climate risks and inequality, both internally and between developed and developing economies. Mott MacDonald, the global engineering, management and development consultancy, estimated a need for USD200bn investment annually by 2035 just to combat losses from climate impacts[5]. This figure has not fully incorporated the additional costs to ensure this new infrastructure is climate resilient.

The proportion of public sector losses in extreme, climate-related events which relate to infrastructure damage is not exactly known, but we are becoming more and more aware of their scale and knock-on socioeconomic impacts. The public and private sectors now need to ensure that all new and existing infrastructure systems are climate and disaster resilient; this requires an efficient integration of PCRs into investment appraisal and valuations.

A 2020 McKinsey report[6] indicated that physical climate risk was reflected in non-linear ways with strong inter-regional variation. Most of the increase in direct impacts to date have come from greater exposure to hazards[7] rather than increases in the mean and intensity of events. As hazard events become more frequent and extreme, the cumulative financial impacts rise. If global emissions are not cut drastically, increasing 'tail risk' seems very likely, with a separate 2016 study, by London School of Economics[8], calculating 'value at risk' of global financial assets at almost USD25tn by 2100, should global mean surface temperature rise to 2.5°C above pre-industrial levels.

With over USD11tn[9] of OECD and G20 countries pension funds and insurers invested in infrastructure, it is imperative that building back better post the 2020/21 pandemic also leads to building back with resilience baked in. Financial institutions are already actively de-risking and using innovative interventions to mobilise private capital with a focus on green infrastructure and clean tech. We now need to provide the right incentives for them to also incorporate resilience building in their real asset portfolios. Indeed, surveys by KPMG and AIMA in 2020 suggested a rising appetite for infrastructure as an investment class which could go some way to 'climate proofing' portfolios with long horizons.

On the public side, policies need to reflect the urgent need for resilient infrastructure spending, including regulations on planning, procurement, investment, competition and transparency. This would inspire market confidence and attract investment to the most needed projects, with governments having to foster new markets and acting as lender of last resort in some cases.

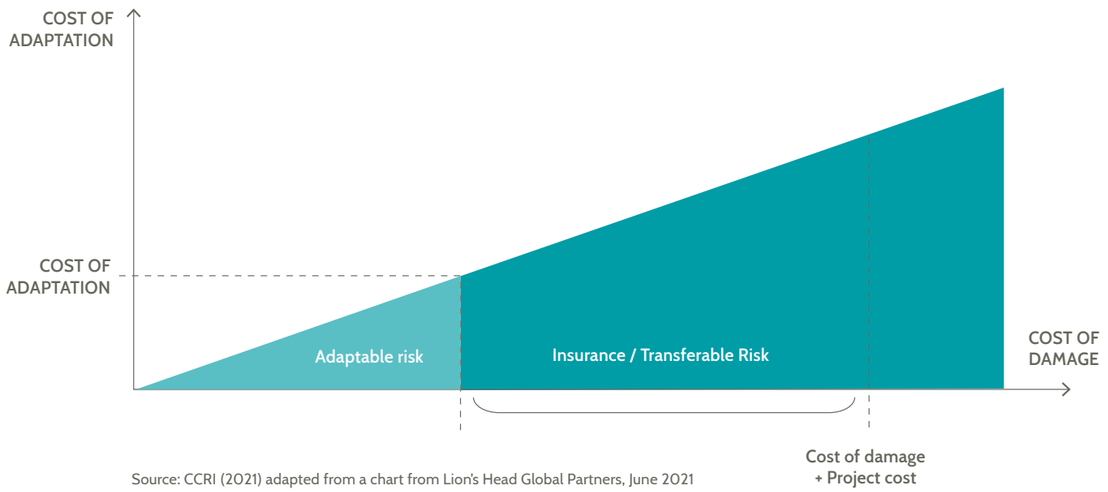
Climate Resilient Infrastructure

Engineers typically look at historical climate patterns to inform their asset designs. Often design is based on minimum regulatory requirements in the project location. There is currently no incentive for engineers, contractors, or investors to exceed these regulatory requirements. Instead, they optimise their proposed infrastructure solutions to achieve the lowest Net Present Value and highest Internal Rate of Return, while complying with regulations. Investing in infrastructure resilience generally results in additional incremental upfront costs. These costs, however, are typically recouped over time, as a well-functioning infrastructure asset will generate a correspondingly improved predictable and sustainable performance. Developing a methodology to quantify the economic, social and financial benefits of incremental investments in resilience will provide a substantial and critical incentive for the financial markets and services to embed resilience upfront.

Climate resilient infrastructure can be achieved through two complementary approaches:

- Building infrastructure designed to withstand the increased physical risks posed by climate change through appropriate design and engineering; and
- Allocating risks which cannot be completely adapted to those best placed to absorb them such as governments, insurers, and investors.

One of CCRI's areas of focus is to address long-term physical climate risks, which cannot be completely designed or engineered out of projects, with the objective of creating financial instruments which allow these risks to be insured or otherwise efficiently allocated in the market. These are variously termed 'unadaptable' or 'unmitigable' risks in project design. As can be seen from the graph, below, there is a theoretical point above which the cost of adaptation (built in resilience) when discounted back to present values, becomes higher than the theoretical cost of downtime, recovery and repair of infrastructure following an extreme weather event. Risk above this point could be transferred through insurance or other financial market mechanisms. Searching for this point is dependent on the quality and precision of forecasts of both chronic climate change and acute and extreme events.



Source: CCRI (2021) adapted from a chart from Lion's Head Global Partners, June 2021

There is a theoretical 'adaptable risk threshold' below which it is economically viable to address increased physical risks through the construction and design of the infrastructure itself. This will reduce the magnitude of the physical impact of climate change on a given project and improve the economics of the project overall (or undertake incremental resilient investments on an operating asset). This could be achieved by mitigating a basic level of risk exposure so that the total amount of insurance or risk allocation needed for the project is reduced, and the range of impacts which need to be 'covered' will be narrower. In insurance terms, for example, it means that the once in five year damages from climate events might be addressed through resilience building and adaptation, leaving the less frequent, but more extreme events to be insured. Eventually, governments may need to step in to insure against the most severe climate events as their frequency and intensity increase.

A combination of adaptation measures for infrastructure (materials, design, size, location) and passing off acute event tail-risks would result in:

- Infrastructure which is physically more resilient;
- Specific new instruments which would allocate the residual risks to insurers, investors and ultimately governments; and
- Lower insurance premiums paid to cover residual risks.

It could make sense to think of the additional resilience costs as equal to the discounted value of savings on insurance premia over the lifetime of the asset (or until certain resilience measures must be reinstated). However, this does not account for change in expectations of intensity and frequency of acute risks over time, and the "thorny" issue of which discount rate to use for the insurance payments.

More climate-resilient infrastructure can improve the reliability of service provision, increase asset life and protect long-term asset returns. Given the uncertainty of future climate impacts, flexible and adaptive approaches can reduce the costs of building-in climate resilience. This will be expedited with the availability of high quality, consistent data, innovative tools for measuring success and more technical capabilities.[10]

Physical infrastructure resilience measures focus on the structure, management or operations, and project managers commonly split solutions into:

GREY

- Traditional, engineered and built systems providing resilience benefits to water, drainage or transportation systems through built structures; and
- Includes enhancements to water systems and treatment plants, storm drains, sewers, shoreline levees, wave attenuation devices, sea walls or tidal gates.

GREEN

- Projects that mimic natural cycles to enhance natural systems or provide other climate risk mitigation; and
- Includes living shorelines, tree preservation /planting, green roofs, rainwater harvesting, bioswales, bio retention ponds, open space preservation, wetland restoration, coral reef restoration, oyster reef restoration or barrier island restoration.

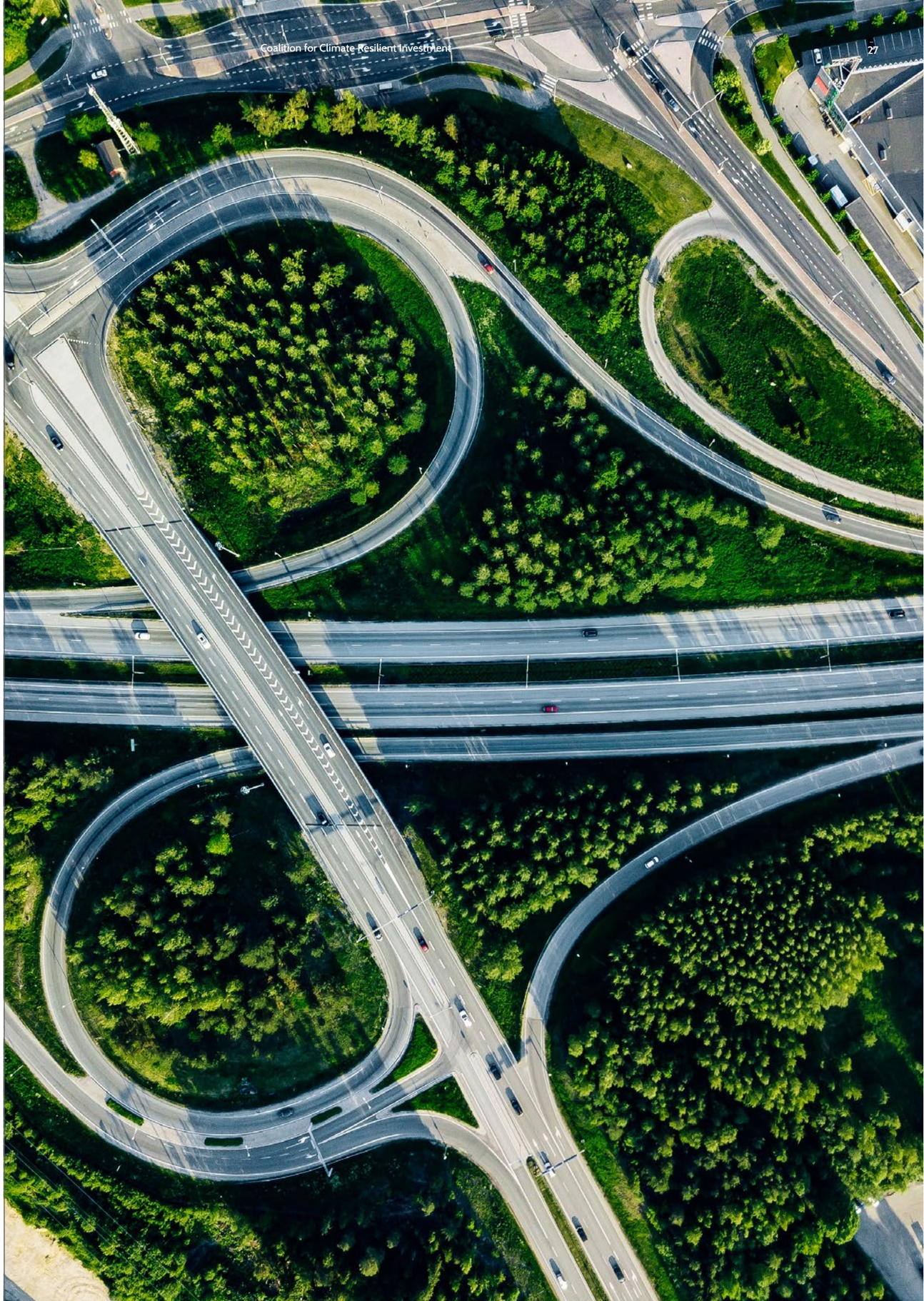
CCRI recognises that for truly resilient and sustainable infrastructure both mitigation and re-allocation of risks are necessary and, in fact, they work best together.

Efforts are being made globally to build more resilient infrastructure, however there is no unanimity on what the best practice measures are, especially with regards to the use of Natural Capital Solutions (also called Nature Based Solutions or, recently, Nature Based Infrastructure). These are increasingly recognised as an economically viable approach to infrastructure resilience, especially in coastal areas where flooding has doubled in the past 30 years.[11] Coastal nature-based solutions provide many co-benefits, such as carbon sequestration, water quality improvement, erosion reduction, habitat provision and support for recreation and tourism industries.[12]

Restoring wetlands, marshes and oyster reefs, and creating living shorelines (plants and natural elements designed to stabilise and protect coastlines) help reduce wave impacts during storms in more temperate zones. Marshland of just over 4m wide can absorb up to 50% of incoming wave energy, whereas concrete infrastructure redirects, rather than dissipates wave energy. In the Gulf of Mexico, wetland and reef restoration are calculated to have delivered USD7 in flood reduction benefits for every USD1 spent on restoration. Here, it is estimated that nature-based solutions could help avert more than 45% of climate risks over a 20-year period, saving the region more than USD50bn in flood damages.[13]

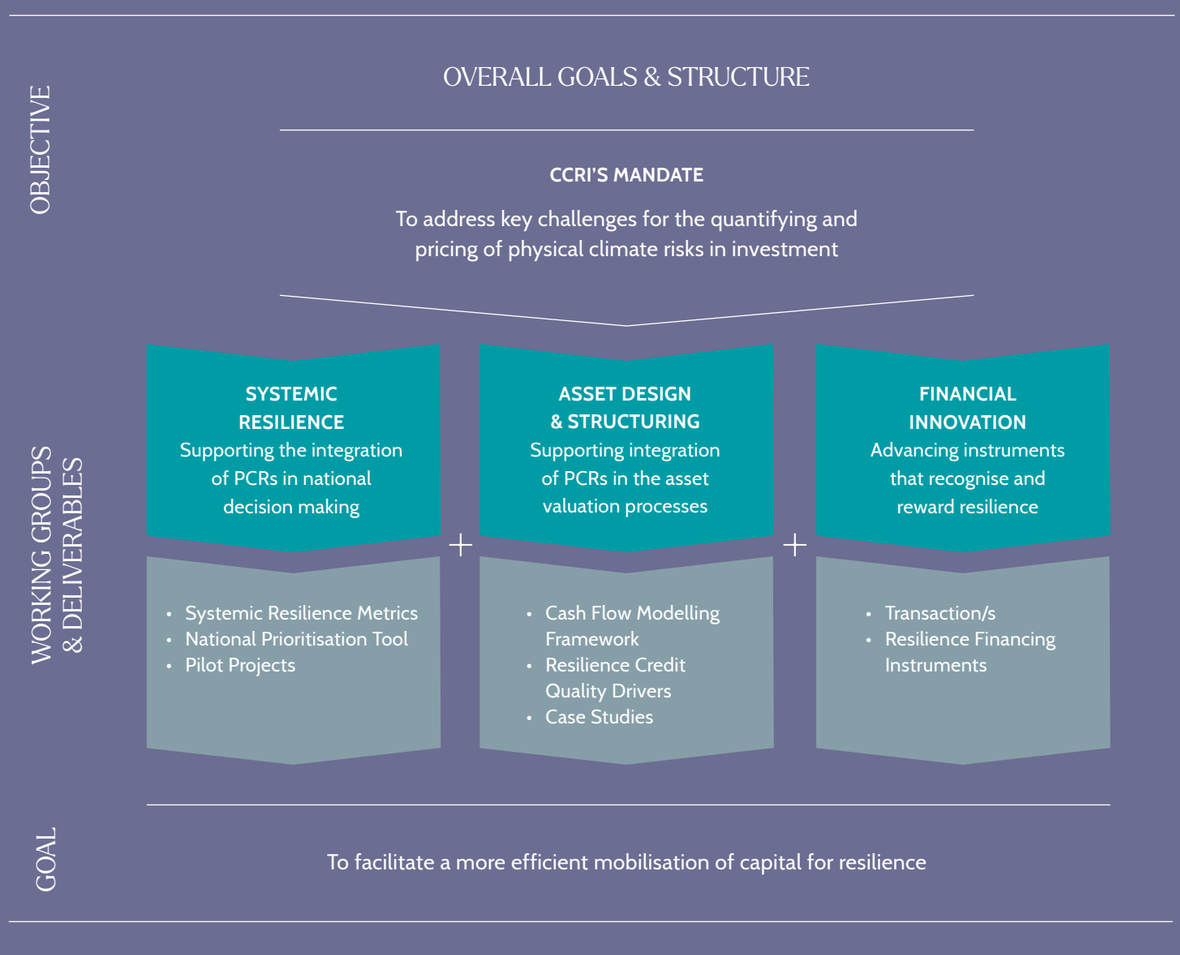
The Special Climate Change Fund (SCCF) of the Global Environment Facility recently approved a USD2m project with the MAVA Foundation to demonstrate the economic case for Nature Based Infrastructure (NBI) to catalyse more public and private investment in adaptation, especially in vulnerable coastal areas.

Natural Capital Solutions can support adaptation against chronic climate change impacts, but they generally cannot protect an asset against an extreme event such as those we are experiencing more frequently.



CCRI Framework

CCRI has set up three working groups to address its mission and achieve its objectives. These aim to address systemic resilience at the national level, ensure PCRs are included in the design, structuring and valuation of infrastructure assets, and to support the development of financial innovations to facilitate the flow of capital towards resilient investments.



1. Systemic Resilience

THE ISSUE

The lack of a global standard for climate resilient infrastructure undermines the ability of public institutions to build an economic and political case around resilience. It makes it difficult to assess, price and allocate PCRs across stakeholders, thus artificially increasing the cost of capital. This ultimately leads to a lack of investable projects and an overall shortfall in resilient infrastructure investment.

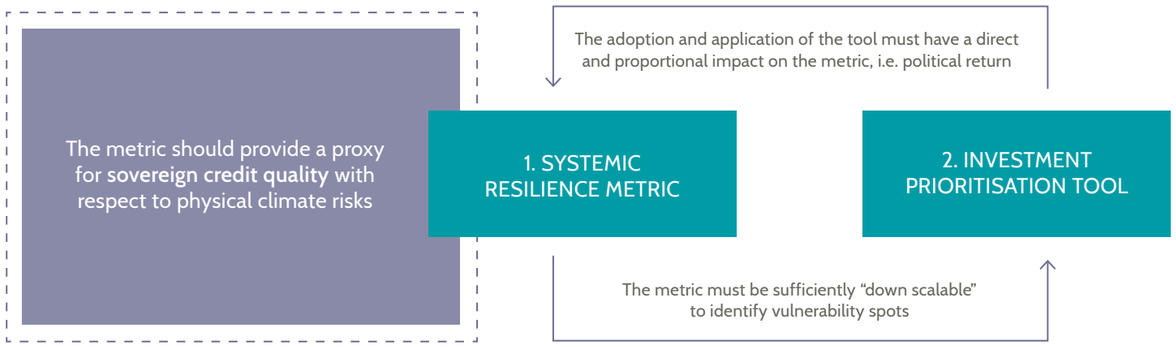
CCRI recognises the urgency for capital to reach the most vulnerable regions and communities, who are on the front line in addressing the physical impacts of climate change. They in turn have important lessons and insights to share and are a significant player in shaping processes that will help better quantify, price and allocate PCRs.

CCRI RESPONSE

CCRI launched the Systemic Resilience Forum ('SRF', one of CCRI's three working groups) in July 2021 with over 50 members – across governments, international organisations, private financial institutions and technical experts. The SRF, formed with the goal of supporting sovereign institutions to better assess and manage national exposure to physical climate risks, brings together perspectives, practice and research from these various partners to help policy and investment decision-makers to:

- Better assess the exposure of **National Value at Risk** from physical climate change; and
- Better manage that risk through improved metrics and prioritisation of investments.

The SRF also seeks to advance trusted and actionable tools and solutions that speak to both public and private sector needs, facilitating increased and consistent capital flows into climate resilient infrastructure. These will be essential to progressing local, national and global efforts to implement national economic development plans, Nationally Determined Contributions and Long-Term Strategies (LTSs). The SRF connects to the Asset Design and Structuring and Financial Innovation working groups by building the economic and business case for investing in resilience and facilitating the development of project pipelines. The outcomes of these working groups will then play a critical role in pricing these PCRs into investment and financing decision making.



DELIVERABLES

The SRF will deliver a tool which allows for both a single measure of **national exposure** and an **investment prioritisation** tool which will provide a dynamic visual representation of exposure within a particular infrastructure system to a defined set of climate hazards. These tools should have knock on effects within the infrastructure network and assist various stakeholders in addressing the social and economic issues implied by a high level of climate risk exposure. We envision a collaborative approach to developing these products, such that solutions are inclusive across countries and within the public and private sectors, customisable, and aligned with global initiatives and processes. They should be used in conjunction with other country- or institution- specific processes and needs.

1. RESILIENCE METRICS

Metrics, such as 'GDP At Risk' and 'Social Value at Risk', are crucial to advancing a more nuanced understanding of macro-economic and socio-economic exposure to physical climate risks and can help embed the use of risk assessment tools in decision-making processes through appropriate incentives.

The SRF is developing a set of appropriate metrics based on current good practices through consultations with countries and CCRI partners to provide an understanding of the systemic PCRs affecting a specific country. The metrics will have the potential to convey how an entity, sovereign or city's macro- and socio-economic risks are reduced, due to the resilient investment prioritisation tool and resilient investment choices. There could also be benefits relating to a reduction in the cost of capital associated with such investments.

2. NATIONAL TOOL FOR PRIORITISATION OF RESILIENT INVESTMENT

CCRI's Systemic Resilience Forum aims to advance the creation, implementation and scaling of systemic resilience assessment and investment prioritisation tool, to facilitate the long-term development of data-driven project pipelines that reflect the needs of jurisdictions.

The prioritisation tool will provide visual and dynamic representations of exposure to physical climate risks within infrastructure networks and systems. This will help national and local decision-makers to understand and manage the exposure of infrastructure systems, assets and the socio-economic implications of physical climate risks. The tool will help identify the priority areas for strengthening resilience, including the identification of options for using nature-based solutions to reduce risks, contributing ultimately to the development of a data-driven project pipeline that facilitates an increased flow of capital towards resilience.

Case Study: Jamaica

Jamaica, a Small Island Developing State in the Caribbean, is the first pilot country where the effectiveness of SRF deliverables in building national resilience is being tested. CCRI, the Foreign and Commonwealth Development Office, the Green Climate Fund and the University of Oxford, in collaboration with the Government of Jamaica, are piloting the development of an investment prioritisation tool. The pilot project examines the exposure of the transport, water and energy sectors to PCRs. The tool will identify where investments in climate resilience should be made and opportunities for nature-based solutions to replace or be integrated with traditional hard infrastructure approaches. These outputs will then inform the development of a pipeline of bankable projects. The technical phase for the pilot was launched at a workshop attended by the Minister of Housing, Urban Renewal, Environment and Climate Change, the Director General of the Planning Institute of Jamaica, and over 70 leading local experts in 2021.

CCRI is in active conversations with six other jurisdictions to scale up systemic resilience solutions.

2. Asset Design, Structure and Valuation

THE ISSUE

Most infrastructure assets are currently not integrating PCRs in their design, structuring and valuation. There are no real incentives to do so given that the impact of such risks is both difficult to assess and likely to take place in the long term. An incremental upfront capital expenditure in resilience may therefore not be financially rewarded. Yet there is potential for a systemic value dislocation relating to infrastructure assets globally as time goes by, as the probability of PCRs increases and their materiality becomes more apparent.

In addition, transferring PCRs to insurers may not be a long-term viable option as risk probability and materiality rise – the cost of insurance may become prohibitive for specific risks and there is no certainty that the insurance market will continue to insure against certain hazards over the long term.

There is currently no recognised methodology for assessing PCRs at the asset level or incentives to report on such risk exposure.

CCRI RESPONSE

The Asset Design and Structuring (ADS) working group aims to develop a methodology for assessing PCRs and integrating them in infrastructure investment decision-making; both at the onset in relation to an asset design, structure and initial investment, and over the life cycle of an asset as it is potentially refinanced and sold to other investors.

The working group has selected a few case studies to assess an asset exposure to PCRs, identify practical resilience options and analyse their value implications. It is organised around different modules covering engineering, revenue impact, insurability, cost of capital and asset valuation aspects.

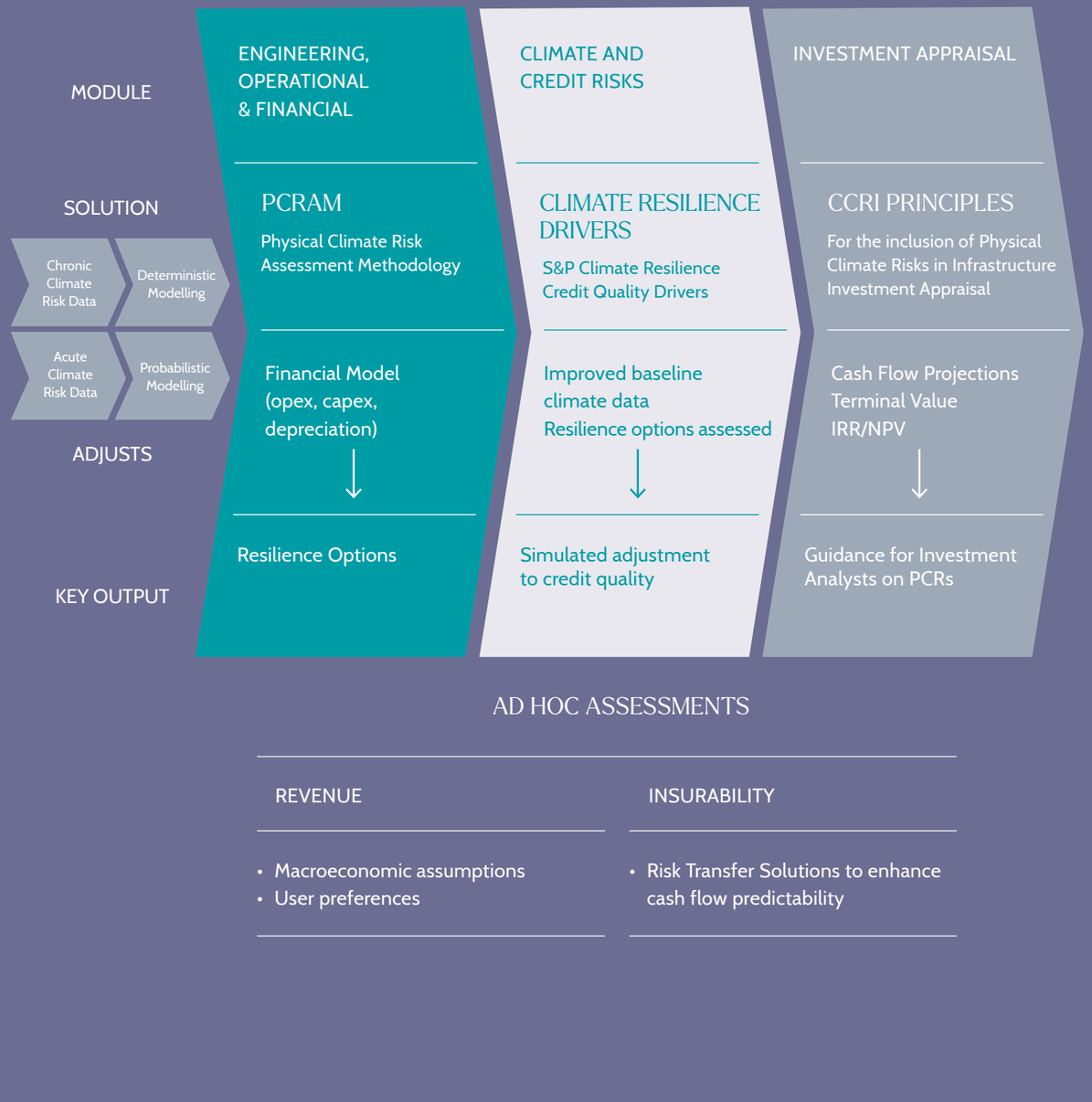
Case studies include a hydropower project in Africa, a nearshore windfarm in Vietnam, a regulated rail link in Europe and a proposed drinking water supply reservoir in the UK. Other case studies are being considered.

In June 2021, Imperial College London, Toulouse School of Economics and University of Washington co-hosted a pilot **Academic Network Workshop** with a group of leading academics to discuss methods for incorporating PCRs into physical asset and project valuation methodologies. The workshop served as an opportunity to bring academics and practitioners together to review the current CCRI case studies and to discuss ways in which to include PCRs in asset valuation theory. **A summary note is available on request.**

DELIVERABLES

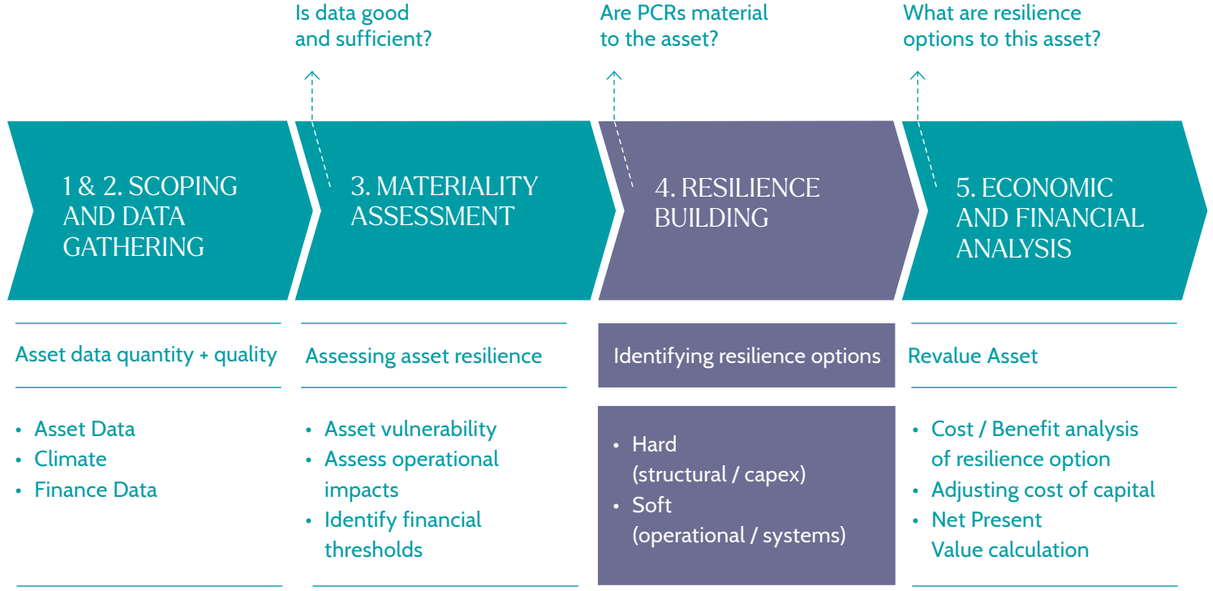
The working group has been working on a set of guidelines, comprising a **Physical Climate Risk Assessment Methodology** and various principles for the inclusion of PCRs in investment appraisal. A **Climate Resilience Credit Quality Driver** assessment is also being developed by Standard & Poor's.

ADS FRAMEWORK



PHYSICAL CLIMATE RISK ASSESMENT METHODOLOGY (PCRAM)

The first version of PCRAM, which aims to assess the baseline resilience of an asset and propose measures for its improvement, has been developed under the guidance of Mott MacDonald with inputs from climate data companies and other participants to the engineering module of this working group. It will be tested and refined by other producers over the coming months. It comprises five stages as explained below.



Source: CCRI (2021), guided by Mott MacDonald

PHYSICAL CLIMATE RISK ASSESSMENT METHODOLOGY (PCRAM) (CONT'D)

SCOPING OF CLIMATE RISKS & DATA GATHERING

The data required includes the location and physical characteristics of the asset, climate data and financial information. A scoping exercise determines the range of PCRs that the asset is exposed to, with their evolving probabilities over time. Financial information is required to stress test the asset and understand under what economic circumstances it may no longer be able to meet its return targets, financial covenants and other financial obligations (in case the asset is financed at the project level). This work is typically undertaken by a climate data analytics provider and an engineering firm working in collaboration with the asset manager. Having completed Stage 2, participants should be able to determine whether the data that has been gathered is sufficient both in quantitative and qualitative terms.

ASSESSMENT OF MATERIALITY

The materiality of an asset's exposure to physical climate risks (and its climate resilience) includes a quantification of the vulnerability of the asset to specific climate risks in terms of physical damages and associated 'make whole' costs, reduction in its availability or usability, and potential increase in its operating and maintenance costs. This is done through an adjustment to the asset cashflow forecast. The exercise is meant to identify materiality thresholds based on a combination of engineering, environmental, legal, commercial and financial parameters. This is best summarised by testing the ability of the asset and its manager to meet their ongoing obligations to their various stakeholders in the face of chronic and acute climate risks.

Stakeholders include customers and users of the asset, regulators and public sector entities which may have granted the right to build and operate the asset with certain conditions, local communities, which may both benefit from and be affected by the asset, lenders who expect their loans to be repaid and investors who are looking to make a return on their investment. At the end of Stage 3, the stakeholder commissioning the study should be able to determine whether one or several physical climate risks are material to the asset.

IDENTIFICATION OF RESILIENCE OF OPTIONS FOR THE ASSET

Once one or more physical climate risks have been determined to be material, a series of resilience options are identified. These options will offer incremental investments to improve the design of the asset (such as improved materials, location, protective barriers or maintenance features) or can relate to changes in operations (such as increased maintenance or planned shutdowns) to reduce its vulnerability. Each option should be quantified, with its range of economic, environmental and social benefits identified.

ECONOMIC AND FINANCIAL ANALYSIS OF RESILIENCE OPTIONS

These options to determine the best course of action, should there be a need to improve an assets climate resilience, should be considered. A cost benefit analysis is undertaken to assess the merits of each resilience option and compare them, based on their ability to shift the occurrence of a material outcome linked to asset-specific PCRs and their rising probabilities.

This is typically done by calculating the revised project internal rate of return (IRR), having initially adjusted an asset cashflow forecast to consider the impact of PCRs. If the revised project IRR incorporating a resilience option is higher than the adjusted climate base case IRR, this suggests that the resilience option is value accretive.

The wider socio-economic and environmental benefits of resilience options may also need to be factored in to ensure that the analysis is comprehensive. This methodology does not consider any adjustment to cost of capital and discount rate which could theoretically result from a de-risking of cashflow forecasts.

PRINCIPLES FOR THE INCLUSION OF PCRs IN INFRASTRUCTURE INVESTMENT APPRAISAL

CCRI is preparing a set of Principles to incorporate chronic and acute PCRs into infrastructure investment appraisal. These Principles aim to provide guidance on the quantification and disclosure of such risks, address the role that insurance can play in transferring them and the requirement to identify resilience options throughout an asset's life. Ultimately, the main objective is to ensure that, as an asset is transferred between investors throughout its life, physical climate risks do not create significant and unexpected value disruption.

CLIMATE RESILIENCE CREDIT QUALITY DRIVERS

S&P Global, comprising colleagues from S&P Global Ratings and S&P Global Market Intelligence (SPGMI), applied as an illustrative exercise SPGMI's credit assessment Scorecard (which broadly aligns to S&P Global Ratings' criteria), to assess the credit quality of projects selected by the CCRI and opine on differences in creditworthiness of the projects with/without climate resilience options. The emphasis of the analysis is on infrastructure projects' exposure to PCRs. The work suggests that credit quality may be positively affected when taking adaptation measures in infrastructure investments into account. There were variations in credit quality for the different climate scenarios that were tested. The CCRI believes that this may have positive implications for the cost of capital of an asset.

Ultimately, tools are being developed to assist practitioners in assessing the materiality and probability of specific climate risks, which should lead to the development of the right incentives and rewards for the integration of PCRs in asset management and investment appraisal.

3. Financial Innovation

THE ISSUE

We anticipate a time lag before the proposed PCR guideline sees widespread uptake amongst finance practitioners, such that **all investments efficiently incorporate PCRs**. This implies that the resilience funding gap will continue to grow unless practical financial solutions are implemented to reward such practices.

THE ROLE OF THE INSURANCE INDUSTRY

Insurance plays a crucial role in promoting climate resilience, from the perspective of both financial risk-transfer and risk exposure assessment and management. With over USD30tn of AUM, the insurance industry also has a broad influence on the development of sustainable and green transition markets, as well as the developing frameworks and taxonomies that ensure standardisation and comparability.

The benefits to insurers from resilient investments should lead to larger potential insurable markets and generally lower claims, leading to higher underwriting profitability. As the 2016 Climate Wise report on Investing for Resilience explains, however, insurers are often faced with reductions in climate insurance premia as they respond quickly to changing levels of risk; a reduction in risk exposure does not necessarily lead to increased profitability in competitive insurance markets with low friction. By contrast, investing in resilience reduces the likelihood over time that certain assets become too vulnerable to PCRs and non-insurable. From a corporate perspective, these types of adaptation and resilience activities can also support brand, reputation and positive stakeholder engagement, as well as reducing the risk of investor activism.

CCRI RESPONSE

Capital market instruments should be developed to **incentivise and reward** projects which can prove they have effectively modelled and integrated climate resilience considerations into their design and structuring phases; and/or operating projects which implement incremental resilient investments. Such instruments are likely to combine insurance and credit products.

Ultimately, these **resilience incentive instruments** can be used to certify that a project has incorporated and priced in PCRs and reinforce a key attribute of infrastructure as an investment asset class - a predictable, secure and long-term source of cash flows.

DELIVERABLES

CCRI has been working with different capital markets and insurance practitioners through its **Financial Innovation Working Group** to design pilot transactions that both fund resilience investments in infrastructure assets and incentivise the efficient pricing of PCRs. The use of parametric insurance solutions is being considered to address bankability issues linked to asset PCR exposure. The working group aims to present a funding plan for a pilot transaction in the coming months.

Solving the valuation conundrum by decoupling time and risk

The traditional methodology for real asset valuation (the Capital Asset Pricing Model, "CAPM", now 60 years old) projects lifetime cash flows and discounts them back to a present value so that those further out, which are more uncertain and therefore riskier, are valued less that those realized sooner. In the model, the expected rate of return is the 'risk-free' rate plus an 'equity risk premium' (the market risk premium x beta for that specific asset type).

The downside of this approach is that it does not allow for a preference for risk over time, or vice versa, as it assumes that:

- Risk and time effects are interchangeable
- All risks are a function of time, independent of source, and
- Risks increase exponentially with time.

CAPM has evolved in complexity over the decades, with additional factors added to improve predictive capacity, but it remains ubiquitous in valuations, despite its limitations - only incorporating non-diversifiable risks, reducing the impact of all risks to volatility and magnifying the importance of the present. NPV calculations still express uncertain cash flows in terms of expected values, with the discount rate incorporating the risk element. Models, therefore, struggle to deal with acute and chronic PCRs expectations, which are both escalating with our understanding of climate change and becoming less predictable due to interactions and tipping points.

CCRI academic members are working on new, pragmatic solutions to this challenging valuation conundrum which attempt to separate risk from the time value of money. In the new paradigm, expected cash flows are assessed for riskiness, reduced accordingly, then discounted by the risk-free rate, theoretically reducing the pernicious time-bias of traditional discounting.

The CCRI's Physical Climate Risk Assessment Methodology (PCRAM) incorporates climate science and engineering to account for potential resilience and adaptation options, thus redefining risk away from the 'mean variance' of Modern Portfolio Theory. PCRAM also leans on behavioural science which identifies the loss-averse nature of most investors and the fact that they are already comfortable with buying insurance products for specific insurable risks and self-insuring others.

New valuation models which treat risks as costs that reduce cash flows, are described probabilistically and then discounted with the risk-free rate alone, effectively decoupling risk from the time value of money. Attributing monetary values to key identified risks (market, physical, technical, political) allows investors to reconnect with the sources of risk, evaluate their effect on cash flows, select appropriate risk management measures and, more importantly, allocate capital more efficiently. This 'cost of risk' method requires deeper analysis, but the resultant 'decoupled' NPV (DNPV) eliminates the distortions of mixing risk and time and could integrate the sophisticated 'market priced' risk data available today. The reward for investors would be better pricing, more realistic expectations of returns, and better-informed investment decisions.

Collaboration

A multitude of stakeholders are affected by, and involved in, creating more resilient infrastructure assets globally. They are all interconnected and CCRI hopes to support these groups to address the resilience issue practically and collectively, eventually setting standards and implementing policies and guidance which make sense holistically. The diagram, on the following page, shows the stakeholders who should be brought into these discussions at the earliest stage.

Stakeholders in Climate Resilient Investment

1. EQUITY AND DEBT

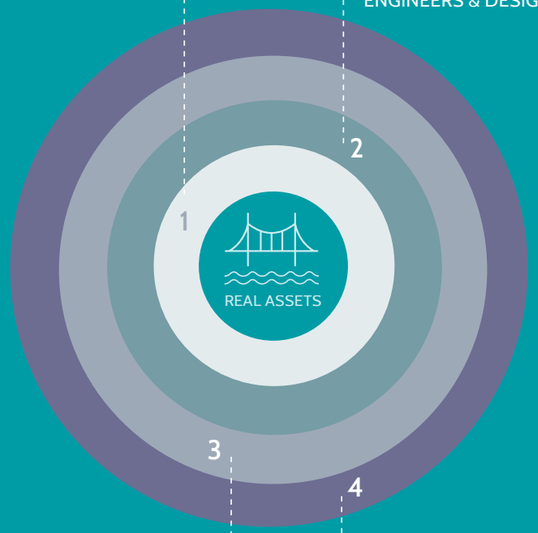
CAPITAL

PENSION FUNDS
INSURANCE COMPANIES
MUNICIPALITIES
GOVERNMENTS
DEVELOPMENT BANKS
RETAIL INVESTORS
CORPORATES

2. PLATFORMS, INTERMEDIARIES AND TECHNOLOGY

FINANCE ECOSYSTEM

INSURANCE INDUSTRY AND ACTUARIES
ACADEMIC INSTITUTIONS AND RESEARCH
INVESTMENT BANKS - BOND & EQUITY ISSUANCE
ASSET MANAGERS
SOVEREIGN WEALTH FUNDS
RATINGS AGENCIES
RISK ASSESSORS
CONSULTANCIES
STOCK EXCHANGES
DATA AND TECHNOLOGY - RISK, AI, GEOSPATIAL
ARCHITECTS, PLANNERS,
ENGINEERS & DESIGNERS



3, NATIONAL FRAMEWORK

NATIONAL

CENTRAL BANKS & FINANCIAL REGULATORS
REGIONAL AUTHORITIES
CITIES
PLANNING
FLOOD MANAGEMENT AGENCIES
SECTORAL REGULATORY & ADVISORY BODIES
GOVERNMENT MINISTRIES
— Power
— Housing
— Transport
— Environment
— Food & Agriculture

4. SUPRANATIONAL FRAMEWORK

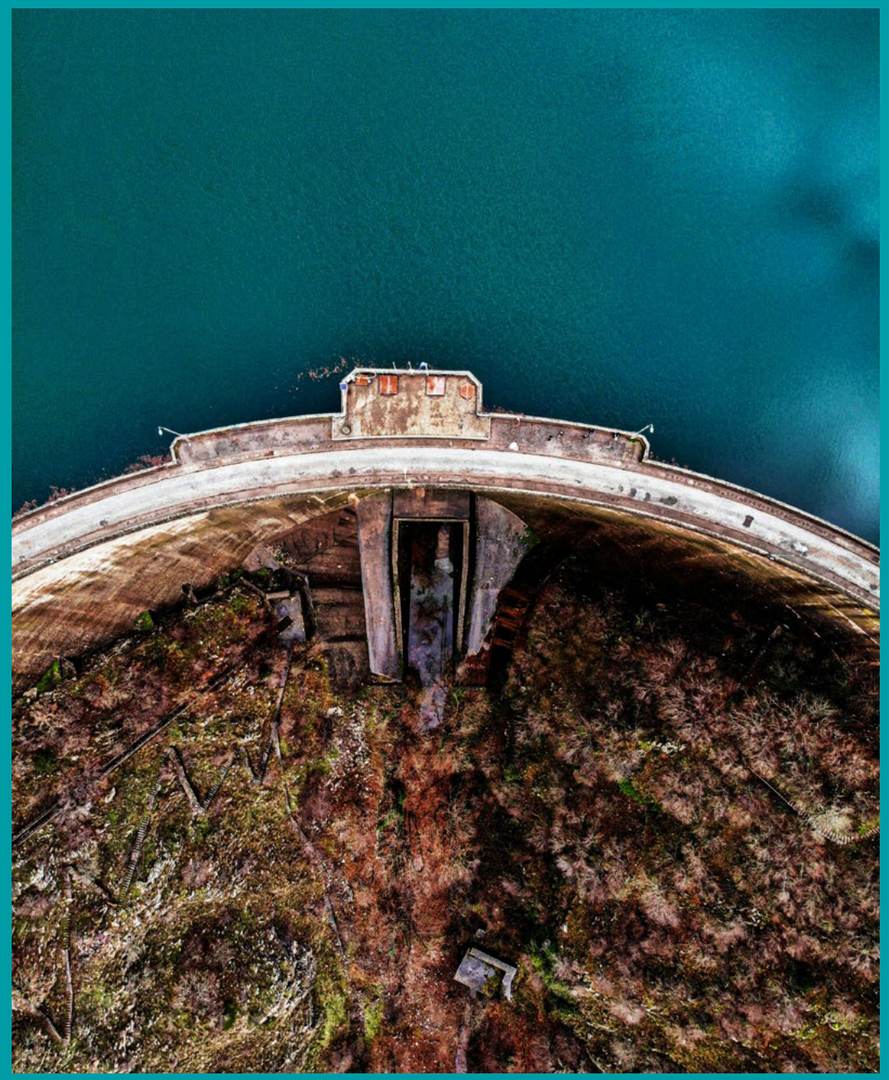
SUPRANATIONAL

UNITED NATIONS
CONFERENCE OF THE PARTIES
G7/20
NGOs
THINK TANKS
MULTILATERAL DEVELOPMENT AGENCIES
GLOBAL SECTORAL COALITIONS

Source: CCRI (2021)

Complementarity with Related Initiatives

CCRI activities complement the many other initiatives, regulatory frameworks and existing analytical frameworks in development. The frameworks we are developing are intended to support key regulatory and analytical initiatives by providing a 'proof of concept' regarding what an efficient pricing of PCRs looks like. Organisations in this area present progress to the Executive Office of the UN Secretary General as the network of partnerships and collaborations grows to avoid duplication and redundancy.



TCFD | TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

The TCFD disclosure recommendations are endorsed by over 1,500 firms representing assets of over USD150tn. The recommendations have already been incorporated into many frameworks and regulations by supervisors. They aim to identify and report on climate-related financial risks in a standardised way, but the link to corporate valuations is still under development. CCRI aims to complement TCFD by developing a valuation framework that incorporates PCRs in the appraisal of infrastructure assets—valuing not only downside risks but also capturing the benefits of climate-resilient infrastructure assets. Investors are expected to incorporate climate-related risks and opportunities into governance structures as well as strategy and risk management processes, using additional climate-related scenario analysis and stress-tests.

Investors are advised to adopt the following eight TCFD-recommended activities which will contribute towards ensuring physical assets become more climate resilient over time:

1. Climate change scenario analysis;
2. Engagement with companies along the value chain;
3. Analysis of evolving legislation on climate change;
4. Risk mapping, materiality assessments and balanced score cards;
5. Enhanced due diligence applied to projects and transactions;
6. Use of an internal carbon price;
7. Risk management plans and integration into overall enterprise risk management; and
8. Adaptation activities ensuring resilience to physical climate change risks supports long-term business strategy.

TCFD is a driving force in mobilising interest in resilience across regions and industries, and CCRI will continue to provide actionable recommendations on how to achieve this.

CDRI
Coalition for Disaster Resilient Infrastructure

The Coalition for Disaster Resilient Infrastructure (CDRI) is a partnership of national governments, UN agencies and programmes, multilateral development banks and financing mechanisms, the private sector, and knowledge institutions that aims to promote the resilience of new and existing infrastructure systems to climate and disaster risks in support of sustainable development.

CDRI's strategic priorities include:

- Technical Support and Capacity-building;
- Research and Knowledge Management; and
- Advocacy and Partnerships.

CCRI and CDRI have developed a strong partnership, rooted in complementarity across respective mandates and workplans. CCRI contributes to CDRI's work from a private finance perspective, while CDRI supports CCRI from its strong positioning in public and international decision-making related to resilience investments.

Fast-Infra

FAST-Infra — the 'Finance to Accelerate the Sustainable Transition-Infrastructure' initiative — aims to close the trillion dollar sustainable infrastructure investment gap, with urgency, by transforming sustainable infrastructure into a mainstream, liquid asset class.

Conceived in early 2020 by Climate Policy Initiative (CPI), HSBC, the International Finance Corporation (IFC), OECD and the Global Infrastructure Facility, FAST-Infra's deliverables include a globally applicable labelling system for investments in sustainable infrastructure assets.

CCRI is an active member of FAST-Infra, focusing its contribution to the development of the resilience category within the sustainable infrastructure label.

GLOBAL COMMISSION ON ADAPTATION

The Global Center on Adaptation (GCA) was founded on September 2018. GCA works as a solutions broker to accelerate action and support for adaptation. Hosted by the Netherlands, GCA engages in high-level policy activities, research, communications and technical assistance to governments and the private sector.

GCA is one of CCRI's convening partners, and as such collaboration was originated before CCRI was launched in 2019. GCA's support to the early steps of CCRI, as well as throughout its execution phase, was and is crucial to CCRI's current momentum.

Blue Dot Network

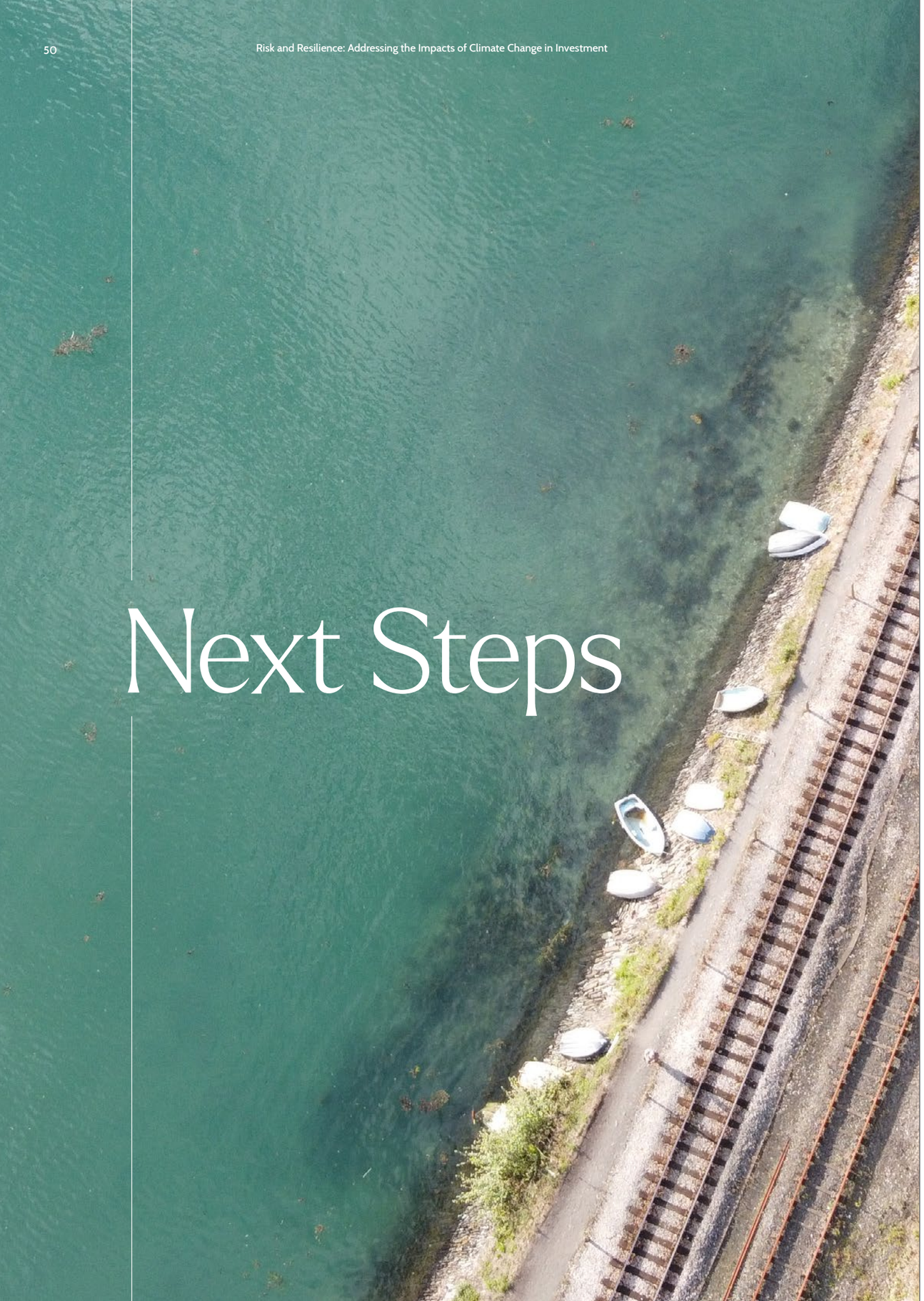
The Blue Dot Network aims to foster high-quality infrastructure investment vital to supporting long-term, sustainable growth and a resilient economic recovery.

This voluntary, private sector-focused and government-supported certification scheme is based on quality infrastructure standards as set out in the G20 Principles for Quality Infrastructure Investment, the G7 Charlevoix Commitment on Innovative Financing for Development, the Equator Principles and guidelines such as the OECD Guidelines for Multinational Enterprises.

CCRI is part of the Blue Dot Network and contributes towards the resilience components of the standards being developed for quality infrastructure.

RACE TO RESILIENCE

CCRI is a Partner Initiative of Race to Resilience (R2R), a campaign to achieve global climate resilience - where people and nature thrive despite climate shocks and stresses. The aim is to strengthen the resilience of four billion people in vulnerable communities by 2030 by helping communities build resilience and adapt to impacts of climate change, such as extreme heat, drought, flooding and sea-level rise in urban, rural and coastal areas. They stress that pledged finance for climate adaptation and resilience falls catastrophically behind that for climate mitigation and decarbonisation and is often left off the agenda completely, with less than 6% of all climate finance tracked globally being attributed to adaptation. UNEP estimates that up to USD300bn will be required annually for adaptation in developing countries alone by 2030. CCRI contributes knowledge, expertise and connects members of the two organisations, as appropriate, to help advance our shared goals and objectives.



Next Steps

The Importance of COP26

The 26th Conference of the Parties to the United Nations Framework Convention on Climate Change will be held in November 2021 in Glasgow, UK. We have seen great progress in target setting to reduce emissions, but further climate change is now inevitable and the most vulnerable countries and communities will continue to be at greatest risk from its impacts, despite having contributed only minimally to the problem. The focus of COP26 is the mitigation and adaptation actions required to reduce the most severe climate change impacts and achieve emissions reduction targets. It also aims to secure the trillions of dollars of financing, both public and private, required to deliver a 'green transition'. Among different elements of the Paris Accord in 2015, Nationally Determined Contributions (NDCs) emerged as an important instrument to reduce emissions and adapt to the impacts of climate change. CCRI is keen to support the translation of NDCs into investable plans.

COP26 looks to unite to avert, minimise and address the loss and damage already occurring from climate change, and support those who are most vulnerable to its impacts while preserving (and ultimately enhancing) the value of financial and real assets. Measures put in place now, such as early warning systems, flood defences and resilient infrastructure, will go some way to protecting people, projects and natural habitats, allowing ecosystems to flourish and societies to thrive. All participating countries are being asked to produce a Communication on Adaptation to discuss the challenges they face and to prioritise the support they need.

From a CCRI perspective, COP26 constitutes a critical stepping-stone in its mandate. Following the initiative's first phase, focused on the development of technical solutions, COP26 will test the ability of CCRI's early deliverables to mobilise interest and commitment from investors, governments and international organisations towards the practical adoption of such solutions in investment decision-making. The partnership of CCRI with the COP26 Unit of the UK Government's Cabinet Office and the Foreign, Commonwealth & Development Office has been transformative for CCRI. The UK government has provided critical support for the resilient investment agenda to advance to its current status.

CCRI at COP26

As a member participant of COP26, CCRI has developed, in coordination with the COP26 Presidency, a programme, comprised of several technical panel sessions on resilience, alongside an art exhibition ('Art + Resilience'), to showcase artwork which speaks to the theme of climate change, risk and resilience. The proposed panel events, aligned to CCRI's three areas of technical focus, will be organised during the Adaptation and Finance days at COP. CCRI is also exploring further sessions in partnership with individual countries to be hosted within their Pavilions.

UN CLIMATE CHANGE CONFERENCE UK 2021
IN PARTNERSHIP WITH ITALY

Long-Term Plans

As we head towards Net Zero in 2050, we must ensure measures are in place so that every financial decision not only takes chronic climate change into account but also incorporates resilience to acute climate risks.

Beyond COP26, CCRI will focus on the practical implementation of its tools and guidelines for infrastructure and expansion to other asset classes. This is to ensure, as we head towards Net Zero in 2050, measures are in place so that every financial decision not only takes chronic climate change into account but also incorporates resilience to acute climate risks. We now know that this will require enhanced disclosure from corporates and the development of new technologies and solutions to assess risks and more easily incorporate available scientific data.

Resilience building will be costly but will also, as with the green energy transition, present new business opportunities, intellectual capital and job creation, reduce vulnerabilities, especially in developing countries, and enhance long-term risk adjusted returns on assets. We need central banks and regulators to begin to build climate change resilience into financial systems and banks, insurers and investors to commit to align to Net Zero and disclose through the TCFD and TNFD frameworks for resilience to be incorporated into all capital investments going forwards.

In addition to our current technical work plans being completed and tools delivered by mid-2022, the following potential long-term goals will be considered and prioritised by members in the coming months:

1. The creation of an investment vehicle which will incorporate CCRI's Physical Climate Risk Assessment Methodology and additional resilience features into project financing;
2. Further advances made in finance theory – new models co-developed by academics and practitioners to promote the integration of physical climate risks into asset valuation and investment decision-making;
3. Consultation on the value of CCRI solutions for climate risk-related regulatory initiatives around the world;
4. Endorsement of CCRI guidelines by institutional and sovereign asset owners globally;
5. Exploration of the justification and potential for delivery of climate risk databases to be available as an open source public good, whilst ensuring continued innovation and that the pace of development of technical tools and methods of analysis are not stifled;
6. The convening and support of further platforms for the sharing of information and ideas in the field of climate resilience amongst all stakeholders in the developing climate-resilient asset class; and
7. For CCRI to have a permanent secretariat and home, and for funding and objectives to be decided by the membership and convening organisations collectively.

Concluding remarks from the Executive Director, CCRI

The successful completion of CCRI's workplan across its three main components (systemic, asset, and financing) will provide end-to-end solutions for integrating physical climate risks in decision-making along the infrastructure investment value chain.

CCRI's solutions are innovative and, accordingly, will require time and further work for their refinement, validation and systemic - and systematic - adoption. However, early delivery of such solutions allow to envisage a future in which we can ensure that every dollar invested will maximise the protection of economic, social and ecosystem value from PCRs, while also enhancing risk-adjusted returns.

The early alignment of traditional and accepted economic markers of value, such as GDP and NPV, will allow for an effective bridging of the gap between private and public approaches for resilience. Practically speaking, this will allow for a targeted redeployment of risk sharing, risk transfer and policy incentive instruments to attract a greater share of private capital towards resilience building.

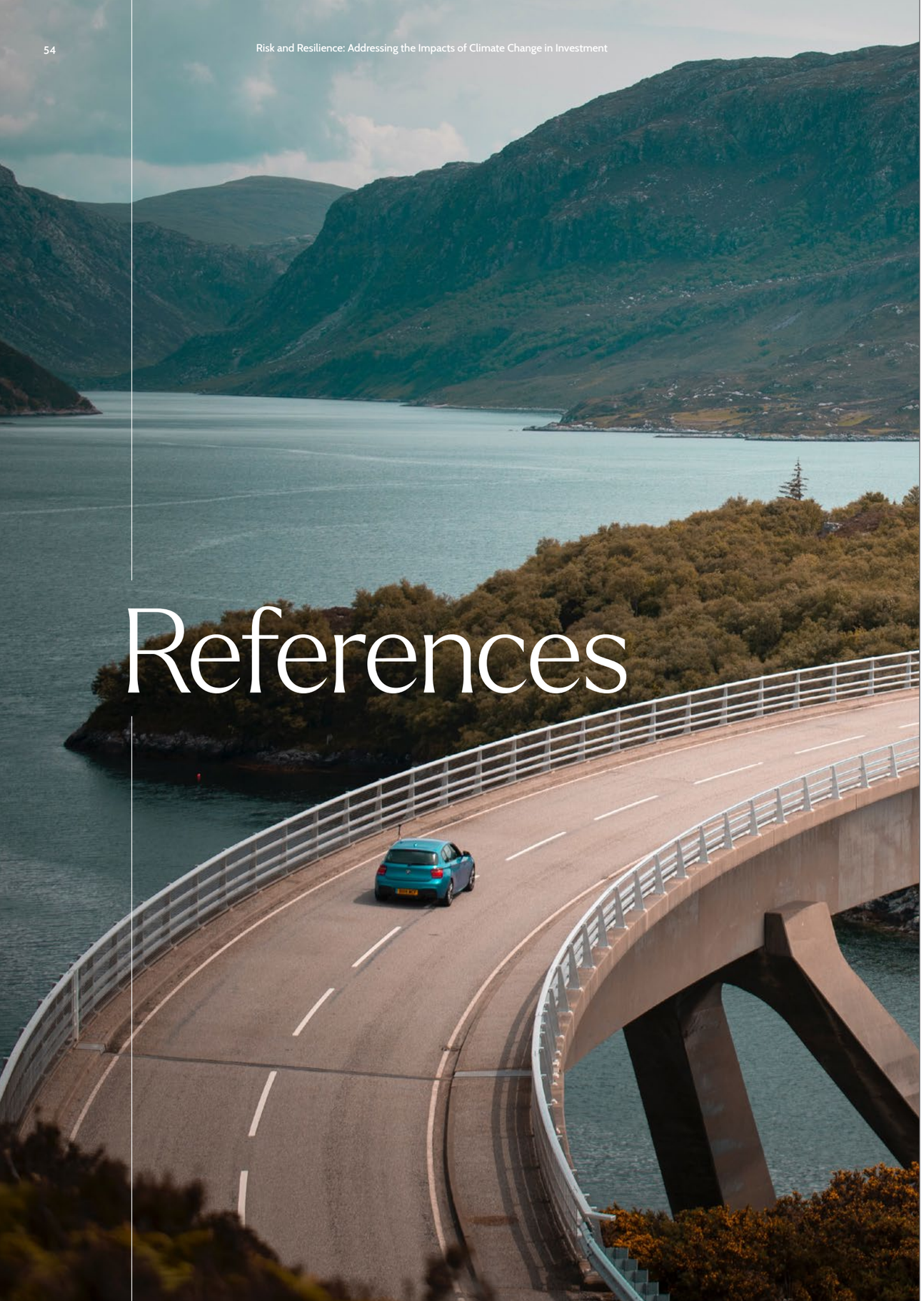
This is no longer a non-OECD, 'vulnerable nation' discussion. As we are witnessing across the world, with recent flooding events in Europe, the US and Australia, climate extremes are causing damage beyond our worst case scenarios. The 'Global Adaptation Gap' is widening. Adaptation in developing countries could require as much as USD300bn per year by 2030,[14] yet less than 6% of climate finance flows annually towards adaptation. Meanwhile, the private sector has not yet been incentivised to fund projects to build resilience, such as natural disaster defences and infrastructure which can withstand the more extreme weather events with no loss of operational efficiency.

The most vulnerable regions and populations do, however, desperately need to begin investing in resilience, in ways most appropriate to their conditions, vulnerabilities and geographies. Dedicated efforts should also be made, without delay, to avoid capital flight from those regions as insurance for climate risks becomes less affordable.

Ultimately, CCRI aims to contribute to redefining the incentive structures of the future and, accordingly, to prepare actors across public and private spaces for a repricing of economic and social activity worldwide once climate risks are properly accounted for and integrated into decision-making. Our mandate is to continue with this work beyond COP26, ensuring the complete delivery of our initial workplan, whilst working towards an extended mandate including the consideration and integration of PCRs in other investment types and asset classes.

CARLOS SANCHEZ

Executive Director for the Coalition for Climate Resilient Investment. Climate Resilience Investment Director at Willis Towers Watson focusing on the integration of physical climate risks in asset valuation and investment decision-making processes.



References

1. https://www.swissre.com/media/news-releases/nr-20210422-economics-of-climate-change-risks.html

2.—https://www.climatepolicyinitiative.org/wp-content/uploads/2020/12/Updated-View-on-the-2019-Global-Landscape-of-Climate-Finance.pdf

3. https://cdn.gihub.org/outlook/live/methodology/Global+Infrastructure+Outlook+-factsheet+-+June+2018.pdf

4.—https://www.oecd.org/sd-roundtable/papersandpublications/Divestment%20and%20Stranded%20Assets%20in%20the%20Low-carbon%20Economy%2032nd%20OECD%20RTSD.pdf

5.—https://www.mottmac.com/download/file?id=24876&isPreview=True

6.—https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/climate%20risk%20and%20response%20physical%20hazards%20and%20socioeconomic%20impacts/mgi-climate-risk-and-response-full-report-vf.pdf

7.—https://www.tandfonline.com/doi/abs/10.1080/17477891.2018.1540343

8.—https://www.lse.ac.uk/granthaminstitute/publication/climate-value-at-risk-of-global-financial-assets/

9.—https://www.oecd.org/environment/cc/climate-futures/policy-highlights-financing-climate-futures.pdf

10.—https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf

11.—https://www.eesi.org/papers/view/fact-sheet-nature-as-resilient-infrastructure-an-overview-of-nature-based-solutions

12.—https://www.eesi.org/papers/view/fact-sheet-nature-as-resilient-infrastructure-an-overview-of-nature-based-solutions

13.—https://www.eesi.org/papers/view/fact-sheet-nature-as-resilient-infrastructure-an-overview-of-nature-based-solutions

14.—https://lightsmithgp.com/news-posts/new-commitments-to-scaling-up-climate-adaptation-investment-announced-at-inaugural-finance-for-adaptation-technologies-solutions-roundtable-fastr-event-during-london-climate-week-2019/

For more information contact
info@resilientinvestment.org

Coalition for
Climate Resilient
Investment

REPORT DESIGN BY JORY&CO