

The Use of Climate Information for Climate Resilience and Adaptation: Current Practices

Xianfu Lu (✉ xianfu.lu@ouce.ox.ac.uk)

University of Oxford School of Geography and the Environment

Research Article

Keywords: Climate information, climate resilience, adaptation, practices

DOI: <https://doi.org/10.21203/rs.3.rs-329862/v1>

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Abstract

With the need for action on adaptation gaining growing attention in public discourse on climate change, the use of climate data from observations and climate model simulations has been rapidly expanding. This includes areas such as designing climate-resilient critical infrastructure and valuating assets of financial institutions. How climate information is applied in these emerging areas of adaptation practice has significant practical, economic and financial implications. Using a set of case studies, this paper illustrates the current practices of how climate information is applied to inform climate-resilient infrastructure development in multilateral climate funds and development banks, and to assess physical climate risks by financial institutions. Two main challenges are identified: a disconnect between what climate data is needed to inform certain decisions and analyses and what is currently available, and a lack of common standards and professional scrutiny around the provision of climate services. Opportunities to help address these challenges are highlighted for the providers and users of climate information.

1. Introduction

After being the “poor cousin” of mitigation for decades, adaptation to climate change impact is gaining increasing attention in public policy discourse on climate policy. As a major sign of enhanced global efforts for adaptation and building climate resilience, the Global Commission on Adaptation (GCA), at the United Nations Climate Change Summit in September 2019, launched a flagship report on adaptation and a year of action (GCA, 2019). The GCA calls for leadership and immediate action to scale up adaptation in eight key systems, ranging from food production, water supply, infrastructure to financing. And indeed, after decades of slow progress on adaptation action within primarily the public sector domain, the past few years have seen a plethora of activities around climate risk amongst the “unusual suspects” in the private sector, largely in response to the G20 Financial Stability Board’s Task Force on Climate-related Financial Disclosures recommendations (TCFD, 2017). In addition, over the past decade or so, notable resources have been committed to supporting climate change adaptation through bilateral and multilateral development institutions, as well as dedicated climate funds (e.g., EBRD, 2020; CIF, 2020; GCF, 2020).

While it is encouraging to see what might be considered as a turning point for adaptation and climate resilience, it is an opportune time to take stock of existing experiences and practices, with a view to ensuring that more actions in the years to come are well targeted, designed and executed. In particular, the use of climate information as a key element in climate risk assessment and adaptation planning, has not been subject to detailed analyses as it deserves. This contribution aims to focus on the current practices in the use of climate information in supporting climate-resilient decision making in two areas of potentially considerable significance. The first is the development of climate-resilient infrastructure by public entities and the second is the climate physical risk assessment by the financial services sector. Given the vast amount of investments expected to be made in infrastructure in the next 2-3 decades (Global Infrastructure Hub and Oxford Economics, 2018), most of which will be in developing countries

and in areas at notable climate-related physical risks, it is critically important to ensure that such investment is climate risk-informed. Meanwhile, the private sector, particularly the capital market, is expected to play an important role to bridge the notable adaptation finance gap (GCA, 2019; UN Environment, 2018). In response to recent development in regulatory frameworks and growing interest in impact investing, assessing and disclosing climate-related physical risks within financial services sector and by large corporations represents a first important step towards capital mobilization for enhanced action on adaptation and climate resilience.

Examples from a variety of jurisdictions and institutional settings are used to illustrate the current state of play. Key challenges and potential areas for improvement as they relate to the use of climate information are discussed.

2. The Adaptation Contexts For The Use Of Climate Information

As relatively early movers on adaptation to climate change, multilateral development banks (MDBs) and climate funds have been working to “climate-proof” their investments in infrastructure and have been jointly reporting on the incremental finance invested in achieving climate resilience (e.g., African Development Bank et al. 2020). This has been driven by the importance of ensuring that considerable investments in building new or upgrading existing infrastructure deliver the expected economic and social benefits under a changing climate.

For MDBs, the consideration of climate-related risks has been incorporated into well established lending operations, from project conceptualization, due diligence to technical design (see Fig.1 for an example of the climate risk management framework for an MDB).

Similarly, engineering and design standard organizations have been working to update existing or develop new design protocols and guidelines to ensure that the design criteria factor in projected changes in key design climate parameters (e.g., [WFEO, 2015](#); [ASCE, 2018](#)). Reflecting the diverse range of considerations with relation to the climate variables, time horizons and spatial scale that are relevant to designing climate-resilient infrastructure, this body of work has largely been sector (e.g. transport, energy) or structure (e.g. roads, power transmission lines) specific. Syntheses of general sector-specific climate change impacts have been produced as a basis for developing new or updating existing design standards. More recently, specific guidelines are being developed to “operationalize” climate-resilient engineering design for major infrastructure in key sectors, such as energy, transport, water supply and sanitation, and flood management. A key element in developing these guidelines involves adjusting the values of key design parameters associated with climate variables to incorporate projected changes in the future.

Assessing and disclosing climate-related physical risks in financial services sector and by large corporations

In June 2017, the Financial Stability Board’s Task Force for Climate-related Financial Disclosures (TCFD) published a set of recommendations for organizations to assess and disclose climate-related risks as pertinent to their financial performance (TCFD, 2017). The recommendations distinguish two broad categories of climate-related risks: transition risk associated with policy and legal, technology, market and reputational implications resulting from transition to a low-carbon economy while physical risks focusing on the physical impacts from extreme (acute) weather events and slow-onset (chronical) shifts in climate patterns. In addition, the recommendations also point to potential opportunities that may arise as the transition towards a low-carbon and climate-resilient takes place. As shown in Fig. 2, there are multiple channels through which climate-related risks and opportunities can affect an organization’s financials. As an initial step to integrate climate-related risks into the mainstream financial risk management framework for financial institutions and corporates, assessment and disclosure marks a major development in private sector action on climate change. Since the publication of the TCFD recommendations in 2017, there have been an explosion of activities around the development of further policy frameworks (e.g. IFRS, 2019; BoE PRA, 2019), technical guidance and case studies (e.g. EBRD & GCA, 2018; UNEP FI, 2019; Climatewise, 2019; UNEP FI 2020), and scenario analyses and stress testing (e.g. NGFS, 2020; Bank of England, 2019). Central to the assessment, reporting, and managing physical climate change impacts for financial institutions and companies inevitably entails the use of climate information. With activities in this domain set to intensify in the years to come, practices to date in these early efforts offer valuable opportunity to identify emerging good practices and opportunities for improvement.

3. Development Of Climate-resilient Infrastructure

current practice in applying climate information

This section will first outline the range of climate-resilient infrastructure activities within public entities, including multilateral development banks (MDBs), climate funds (e.g., Green Climate Fund, or the GCF), and major public infrastructure management authorities. These include, among others:

1. Integrating climate resilience into major infrastructure project development process through climate risk screening and technical due diligence;
2. Demonstrating climate resilience benefit of infrastructure projects as a justification for grant or highly concessional finance;
3. Developing new or updating existing design guidelines for specific types of structures (e.g., roads, flood barriers)

All these activities involve the use of climate information – observed, historical trends and projections for future time horizons. Since currently there are no widely adopted standards specifying “what” and “how” climate information should be used in planning and designing for climate-resilient infrastructure, it is worth exploring, in some detail, the spectrum of current practices, with a view to identifying emerging good practices and areas for improvement.

A set of 3 case studies are introduced to illustrate the range of ongoing practices. These case studies are discussed around the following key features related to the use of climate information:

- Decision context and decision question(s)
- Entry point (e.g. climate risk screening, climate rationale, detailed risk assessment, technical design, cost-benefit analysis) within the decision process
- Use of climate information
 - Variables
 - Spatial scale and resolution
 - Time horizon and temporal resolution
 - Source(s) of information
 - Entities involved (in the sourcing and application)
 - Quality assurance procedure (if any)

Case study 1: Demonstrating climate rationale and additionality (GCF project proposal)

Using a recently approved project, this case study looks at the ongoing practice around the use of climate information in adaptation project funding proposals under the Green Climate Fund. In particular, discussion will focus on how observed trends in past climate and projected changes in future climate are being used to develop the “climate rationale”. In addition, current practice on the use of climate information in performing cost-benefit analysis for proposed adaptation interventions with a view to establishing the “additional” cost. It highlights that

- Observed climate trends, particularly those associated with precipitation (leading to droughts, variability in water availability, flooding), have been used to provide the climate narrative for infrastructure projects which are proposed either as a solution entirely to address climate change impacts (e.g. flood protection schemes) or requiring additional climate resilience measures to ensure that they are fit for purpose under a changing climate;
- Projections of future climate, often at local scale, are used to inform the design of climate-resilient climate-sensitive infrastructure component(s), as well as to assess the (additional) cost of proposed resilience interventions;
- Quality of climate information, and the robustness of data sourcing and application vary widely amongst GCF project proponents, reflecting the limited in-country technical capacity and access to “fit for purpose” datasets in some countries including SIDs and LDCs;
- Although it is relatively less important to have a “perfect” climate rationale or an “accurate” estimate of (additional) cost, the design of long-living infrastructure needs to be supported by more systematic approach to the use of climate information.

Case study 2: Integrating climate change impacts into infrastructure investment loans (MDB)

This case study features the processes and practices within MDBs to mainstream the consideration of physical climate change impacts within operational cycle for infrastructure investment loan projects. It highlights that

- MDBs have been leading the way in operationalizing the mainstreaming of adaptation and climate resilience in investment decisions through the provision of technical as well as financial resources, capacity building and peer learning;
- The use of climate information has been improving but remains ad hoc and lacks in standard QA/QC procedures;
- Considering the large volume of financial investments and the potential consequences of critical infrastructure failure due to adverse impacts of climate change, it is vital that the use of climate information in informing infrastructure development be strengthened and subject to improved QA/QC procedures

Case study 3: Developing climate-resilient design guidelines (The Port Authority of New York and New Jersey - PANN)

This case study looks at the step-by-step guide developed by the Engineering Department of the PANYNJ (2018) for factoring in projected sea level rise (as an amplifier for coastal flooding) in the design of relevant infrastructure under its management. It highlights that

- An expert panel on climate change was behind the provided projected changes in local sea level;
- The guidelines outline a step-by-step process to factor in sea level rise in the design of relevant structures, while remain explicit about the caveats, including:
 - Factors other than sea level rise, such as changes in the profiles of extreme precipitation and heat events, are not yet incorporated;
 - Mid-point estimates of mid-range sea level rise projections are used for calculating the design elevation;

Users may decide to adopt different design values upon consideration of specific contexts

4. Assessing And Disclosing Physical Climate Risks By Financial Institutions And Corporations

current practices in apply climate information

This section focuses on the current practices around the assessment and disclosure of physical climate risks by financial institutions and corporates in response to the TCFD recommendations. In particular, some of the tools and methods being developed and offered by commercial service providers for physical risk assessments are discussed as they relate to the sourcing and use of climate information. Three case

studies are used to discuss the broad categories of analyses being carried out in the context of the TCFD recommendations and the way climate information is used to drive the analyses.

Case study 1: Correlation studies

This case study discusses a relatively new approach to assessing potential impacts of climate change for financial assets. As shown in Fig. 3, a growing body of research shows that climate-related hazards such as floods, droughts, windstorms, and wildfires can impact bank portfolios via property values, farm revenues, loan delinquency rates, mortgage approval rates, and other indicators. A worked example on changes in property values prior to and after wildfires is used to describe how the technique works and how climate information is sourced, processed and used in the correlation analysis.

This case study highlights that

- Observed relationships between pairs of financial performance metrics of assets and climate-related events can help provide early indications of a change climate and its impacts on assets hence help calibrate forward-looking physical climate risk assessments, as well as shed light on emerging opportunities for financial institutions to support their clients in building climate resilience through adaptation measures;
- Given that the approach is based on observed data which financial institutions are familiar with and less dependent on climate model-based information, it might be a good entry point for physical risk analyses while it may also help facilitate internal discussions on the possible pathways that climate events and phenomena affect financial values of assets;
- Climate expert inputs would be helpful to establish the physical narratives between large scale climate events (e.g. ENSO), regional and local climate conditions (e.g. rainfall and temperature), impacts on operations and value chain, and financial metrics of assets, so that the correlations unveiled in the analysis are well understood and physically sound.

Case study 2: heat mapping (portfolio level analysis)

This case study looks at the way that portfolio level physical risk is assessed. This approach is much less data intense and intends to provide an overview “heatmap” of potential risks within a portfolio. It links a range of climate (e.g. precipitation, wind speed) and climate-related (e.g. landslide, water stress) to a set of sector-specific vulnerability indicators (e.g. transportation routes, market demand). Fig. 3 below illustrates sensitive levels (i.e. low, medium, high) of different energy sub-sectors to vulnerability indicators.

This case study highlights that

- The heatmapping approach provides an effective starting point for organizations to gain an overview of potential physical climate change impacts, as a basis to identify climate risk “hotspots” and prioritize further in-depth risk analyses and management efforts;

- Projected changes in relevant climate and climate-related parameters are used in qualitative forms (e.g. more severe water stress, increase in relative humidity) rather than quantitative, which places less demand on the sourcing of relevant data;
- For the resulting heat maps to be technically sound, insights will be critical on which climate and climate-related changes would directly affect vulnerability indicators and how sensitive each sector/sub-sector is to the range of vulnerability indicator;
- In relation to the point above, ideally the heatmapping is conducted by firms themselves so that the key indicators and sensitivity scores could be determined with industry/sector insights. But given the staffing constraints and technical complexity of the exercise, inputs from firms tend to be limited and interactions between firms and external service providers often focus on the interpretation of heatmapping results;
- On the grounds of commercial confidentiality, commercial service providers do not make public the critically important list of climate and climate-related information within the heatmapping tools. Although such information can be made available to firms procuring the services, the lack of public scrutiny prevents thorough evaluation of the use of climate information hence undermines public confidence of the results.

Case study 3: deep dive (asset-level analysis)

This case study looks at the in-depth analyses carried out by investors and lenders alike to assess the climate physical risks as well as financial impacts on properties within 12 real estate portfolios worth \$12 trillion. Discussions focus on how climate change scenarios are selected and used in conjunction of natural catastrophe models. As shown in Fig. 4, projections of climate change for future time horizons, typically 30-35 years (a commercial mortgage term offered by some lenders), are integrated into “traditional” natural catastrophe models to assess the physical damage to properties. Physical damages are then “converted” to financial impacts, measured as property values and/or loan-to-value ratios.

This case study highlights that

- To reflect the changing risk profiles under future climate, natural catastrophe models which traditionally work with observed catastrophic events, have started to incorporate projections of climate change;
- Current practices heavily depend on the assumptions made between changes in the frequency and magnitude of extreme weather events (e.g. storms, hurricanes) and projected global temperature change, which is an area of active scientific research and represents considerable uncertainties;
- Due to the commercial nature of the majority of available catastrophe models (been used by the insurance industry to model risk profiles), there has been limited transparency around the sourcing, post-processing and underlying assumptions made about climate change scenarios used as inputs to the modelling;

Given the considerable implications (e.g. pricing of insurance and capital, evaluation of assets) of this type of analyses, it is imperative that industry standards are developed to define basic principles for the selection and use of climate information, and for transparency on data sources and key assumptions made.

5. Challenges Emerging From The Current Practices

From the discussion on ongoing practices as illustrated by the case studies, two main challenges can be identified: a disconnect between the climate data needed to support the climate-resilient investment decisions and physical climate risk assessment at asset level and what is currently available; and a lack of common standards and professional scrutiny around the provision of climate services. Both issues are discussed in Fiedler et al. (2021) in the context of integrating knowledge of climate change risks into financial decision-making and disclosures.

5.1 A disconnect between what is needed and what is available risks malpractice

As adaptation and physical climate risk management are mainstreamed into key investment decision making and financial risk management processes, the climate information needed to support these decisions requires more nuanced considerations. As illustrated in the case studies, most of the analyses used to inform climate-resilient design of infrastructure and the deep-dive assessment of physical risk of financial assets require climate projections from climate models that is not currently available with sufficient level of confidence or credibility, particularly with relation to:

- Temporal resolution: daily or sub-daily data is required for flood risk analyses while data climate model simulations is typically only used for analyses at monthly or seasonal scale particularly for variables related to precipitation;
- Spatial resolution: often data for specific location is needed for real estate portfolio risk assessments but climate model outputs are not intended to provide robust projections at scales finer than tens of kilometres at the most;
- Time horizon: certain financial risk analyses and decisions often focus on a near time horizon (e.g., impacts of extreme weather related supply chain disruption on the near-term valuation of a food processing business) while climate model signals are not sufficiently robust over the next two decades

If their implications for adaptation decisions made are not explicitly documented or openly scrutinized, these apparent mis-matches between what is needed and what is available (and used) have the potential to lead to maladaptation and mis-information.

- **A lack of common standards and professional scrutiny undermining confidence**

With the increase in demand for technical support to carry out climate risk assessments, adaptation and climate-resilient development planning, a thriving industry of climate services has emerged, particularly in

Europe with significant public investment.[1] But due to the diverse contexts within which climate information is used with many emerging from a relatively new sphere (such as informing investors in their financial risks arising from physical climate risks), there are no common standards for climate information and the associated professional obligations on the part of information providers. As a result, there is little incentive for providers of climate information (particularly those operating on commercial basis) to be transparent and explicit about the data being provided including any caveats and their implications for the relevant decisions. As a result, there has not been any formal evaluation or professional scrutiny of the quality of climate information being provided and the way such information is applied. Many For the benefits of the expanding user community and the confidence in the emerging climate services industry, there is an urgent need to develop a set of common standards for climate services. Such coherent standards would provide a common framework to monitor and value climate services being provided and their application. Efforts have already been initiated, for example, under the UK Climate Resilience Programme.[2]

6. Opportunities And Way Forward

The plethora of activities around adaptation and climate resilience, witnessed over the past few years from both the public and private sector domains, are cause for comfort and encouragement. There has been a genuine sense of determination, on the part of policy makers and practitioners to tackle the inevitable impacts of climate change. The ground has been prepared for much intensified adaptation efforts in the years to come. But much could be gained in making these efforts count. Among others, the following represent opportunities to improve the current practices for the provision and use of climate information in supporting climate-resilient and adaptation decision making.

6.1 Provision of climate information

On the supply side, climate scientists and researchers could be more mindful of and transparent about the implications of uncertainties associated with climate information for specific decision contexts or questions. This may entail the development of a comprehensive mapping of climate resilience decisions and the associated type of climate information required. Based on this, high level good practice principles could be developed to define what is acceptable and what is to be avoided. Public bodies (e.g. standard organizations, planning authorities, public procurement agencies) could work with research institutions to develop common data sources and associated access protocols.

For commercial service providers, to the extent possible, it would be helpful to disclose details of key datasets, particularly if they are from public sources. It would also help inspire public confidence to be open about the key assumptions made about the selection and use of climate information in their off-the-shelf analytics offerings.

6.2 Use of climate information

Given the wide range of climate resilience decision contexts and subsequently the highly varied climate information needs, much could be gained through coordinated efforts to develop (industrial) standards and good practice guidance. First, there is a need to update existing infrastructure design standards to reflect the changes in climate-sensitive design parameters. The responsible entities for doing this would differ across jurisdictions. But bilateral and multilateral development agencies, among others, can play an important role here, in terms of supporting technical and institutional capacity development, facilitating the sharing of knowledge and good practices.

Second, there is a need to develop sector- or industry-specific good practice guidelines on the use of climate information to support climate-resilient decision making within existing sector policies and practices. Although notable progress has been made in some sectors (e.g. examples from MDBs, national guidance from NZ, UK, ISO climate risk assessment standards), much could be done to make this more systematically and more specifically on the type of climate information required to support certain decision questions.

Last but not least, for the users of climate information, it is important to be clear about the climate resilience decision question, be able to articulate the appropriate type of climate risk analyses and specify the required climate information. This could be achieved through working internally within organization, with or without support of external experts, to thoroughly understand the potential impact channels of climate change on the organizations' strategies, policies and ongoing operations. For example, many corporates and financial institutions have been creating new roles with climate risk management mandate, or working with expert service providers to build internal technical capacity. Once organization is in a position to ask the right questions around what climate information is needed (instead of what is available), the providers of such information can work with more clarity and focus to meet the needs. This would also enable more meaningful interactions between the developers and users of climate models, hence initiating a virtuous cycle of co-production of climate information.

6.3 Towards a climate information ecosystem

Last but not least, given the technical complexity and deep uncertainties involved in the provision and use of climate information, one would be utterly disappointed if (s)he looks for ready answers to climate risks. It is clear that there is no easy replacement of ongoing dialogue and engagement. There needs to be much more direct engagement between climate science community and businesses. It is often attempting to out-source highly technical tasks such as detailed climate-resilient design of critical infrastructure or physical climate risks of a portfolio of financial assets. As willing as the contracted service providers are to do their best to deliver, it pays to have ongoing discussions on the business or decision context and to help identify what matters most when it comes to manage uncertainties associated with climate model-based projections about future risks. Such ongoing dialogues would be facilitated through the recruitment of in-house climate risk roles within major corporate and financial institutions. A more engagement-based, as opposed to one-off contractual, approach to sourcing and

using climate information would both enable the appropriate use of robust climate information and drive the scientific innovation that the business community needs.

As climate risk management is mainstreamed into public and private sector decision making in the years to come, a new generation of professionals need to be trained to serve as “climate translators”. In this regard, universities and research institutions have a real opportunity and responsibility to produce a new generation of climate services professionals. In writing his preface for the country’s climate resilience and recovery plan 2020-2030, the Prime Minister of the Commonwealth of Dominica calls for educational institutions to guide students into careers and professions that respond to areas of greatest national needs (Government of the Commonwealth of Dominica, 2020).

Declarations

Acknowledgement

The author wishes to thank all the constructive and insightful comments on an early draft of the paper from the participants at the Climate Information for Adaptation workshop organized by the University of Leeds and London School of Economics on 19-21 October 2020.

Funding: not applicable

Conflicts of interest: The author declares no conflict of interest.

Availability of data and material (data transparency): not applicable

Code availability (software application or custom code): not applicable

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Figures

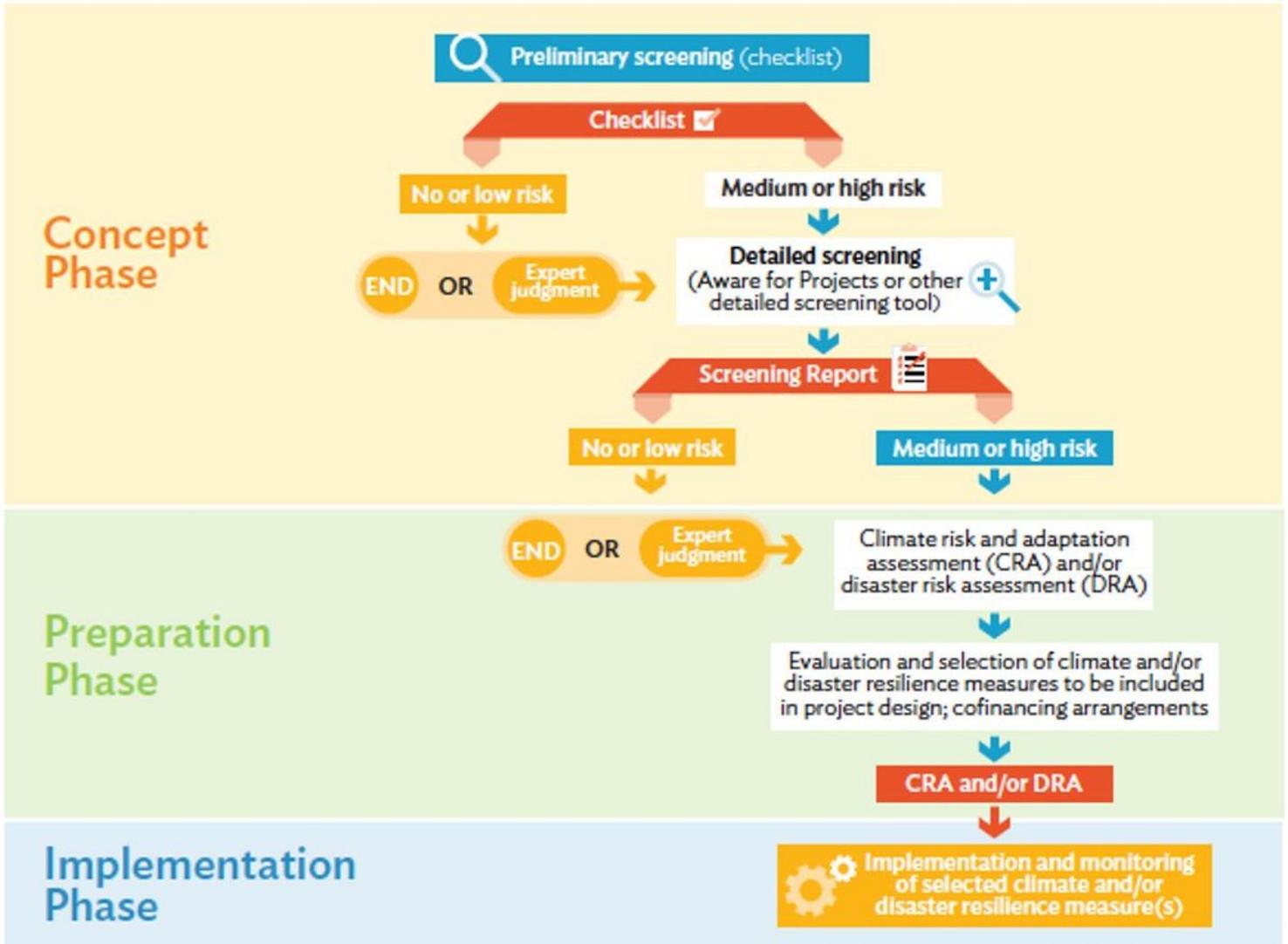


Figure 1

Asian Development Bank's Climate Risk Management Framework Source: Lu (2019)

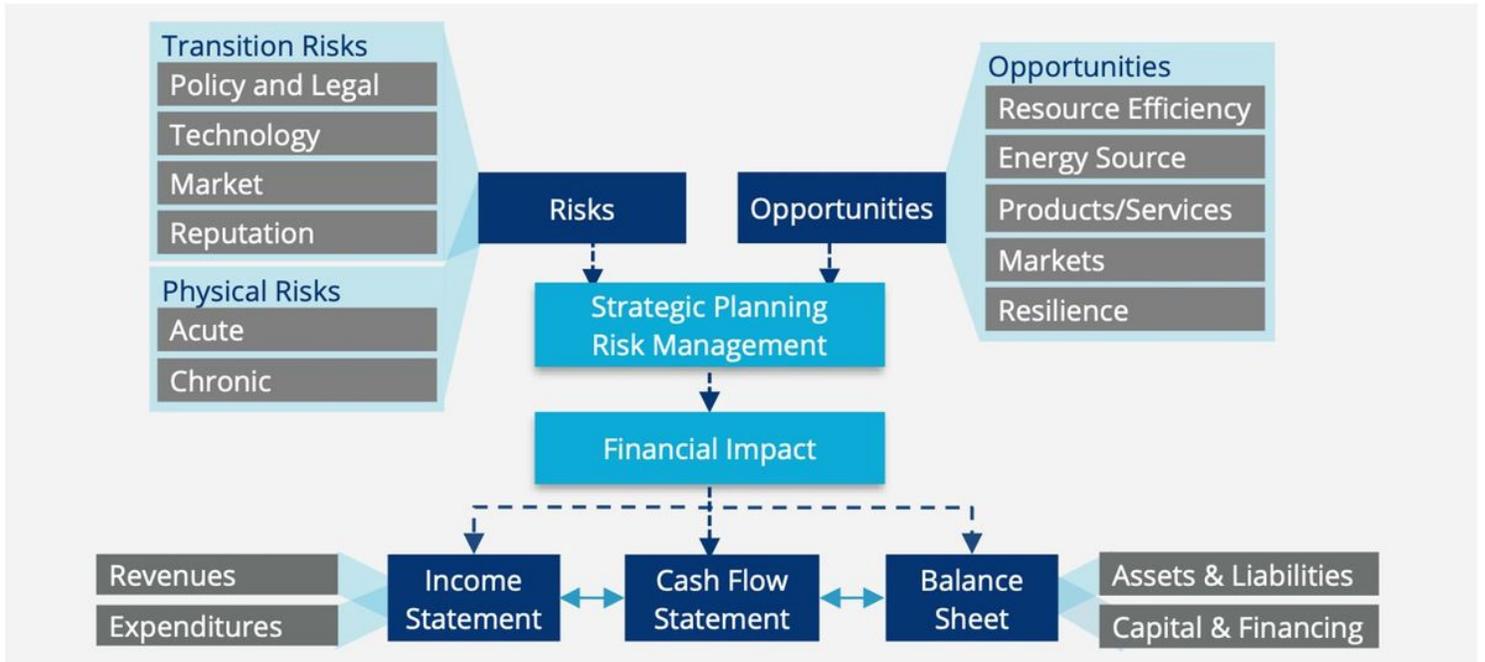


Figure 2

Climate-Related Risk, Opportunities and Financial Impact Source: TCFD (2017)

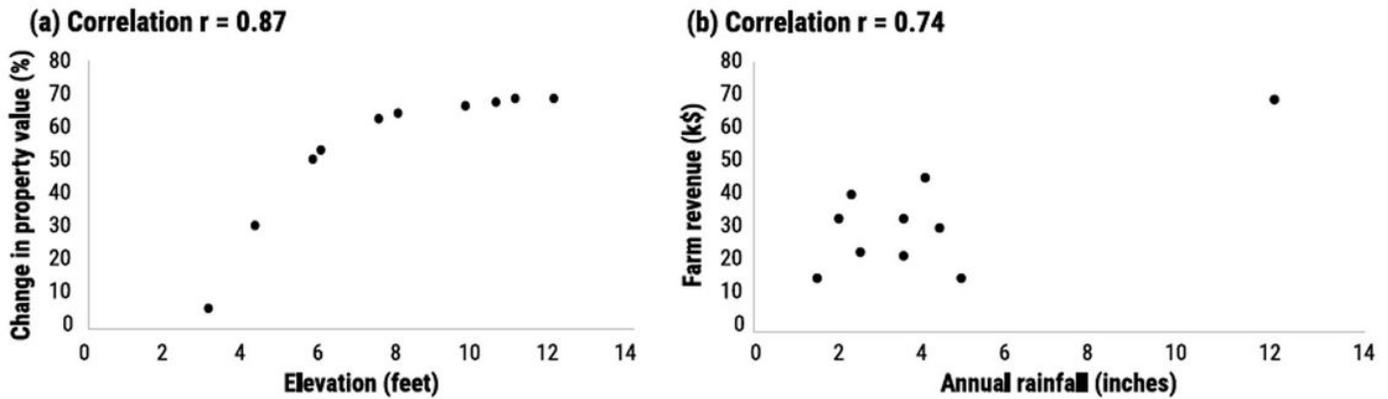


Figure 3

Scatterplots of artificial data illustrating correlation between (a) property value and elevation and (b) farm revenue and annual rainfall. The Pearson correlation coefficient (r) is given for both Source: UNEP FI (2020)

		Sub-sectors				
		Thermal power stations: natural gas	Biomass power stations	Solar CSP	Hydropower	Power transmission & distribution
Vulnerability indicators	Natural resources	High	High	Low	High	Low
	Energy supply	Med	Med	Low	Low	High
	Climate sensitive supplies	Low	High	Low	Low	Low
	Transport routes	Med	Med	Med	Med	Med
	Assets & processes	Med	Med	Low	Med	Med
	Market demand	High	High	High	High	Med
	Environment & social impact	Med	Med	Low	Med	Low
	Labour health & productivity	Low	Low	Med	Med	Med

Figure 4

Examples of vulnerability indicator scores for energy sub-sectors Source: UNEP FI (2020)

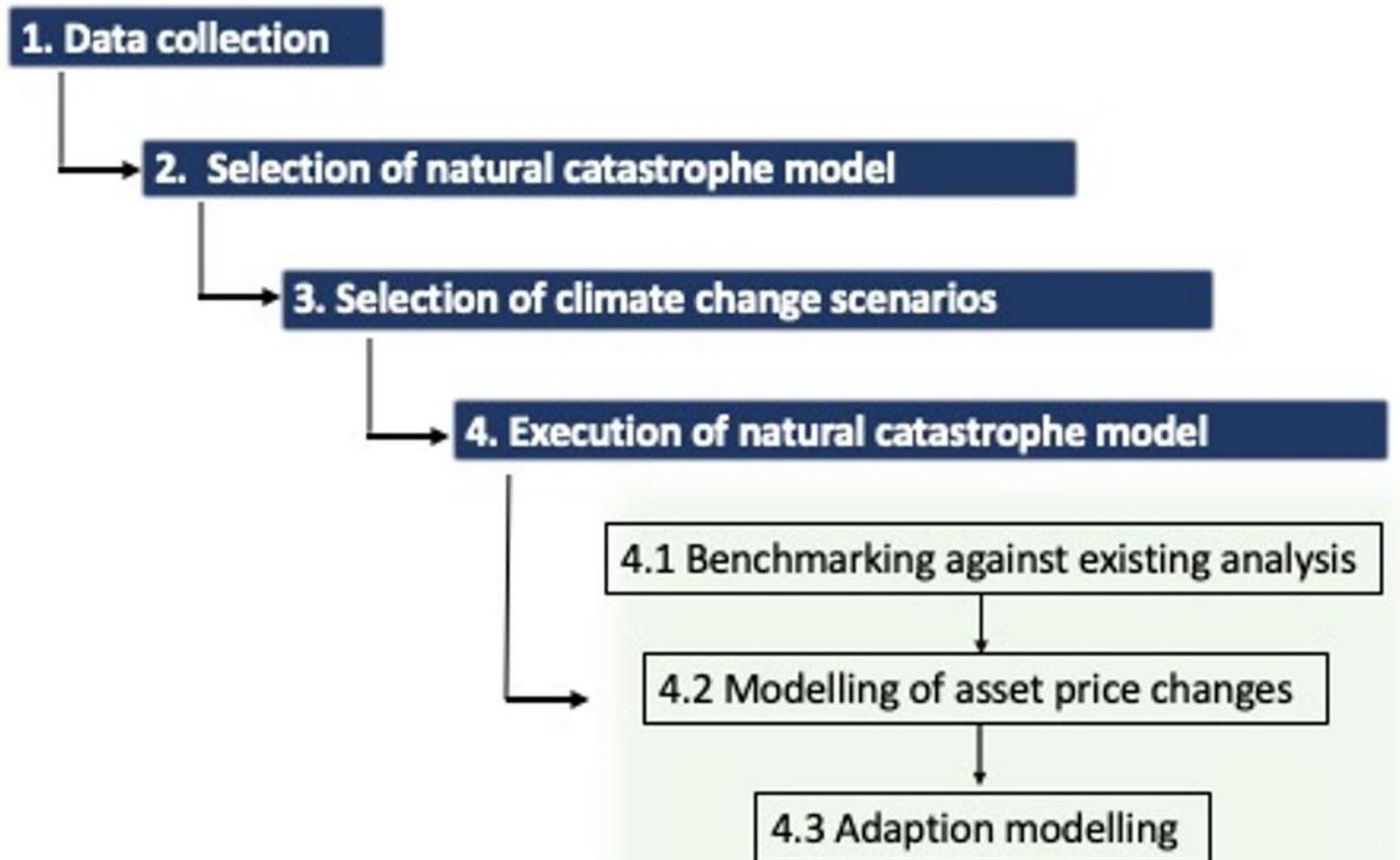


Figure 5

Key step for investors and lenders in modelling physical risks of climate change Source: Adapted from Climatewise (2019)