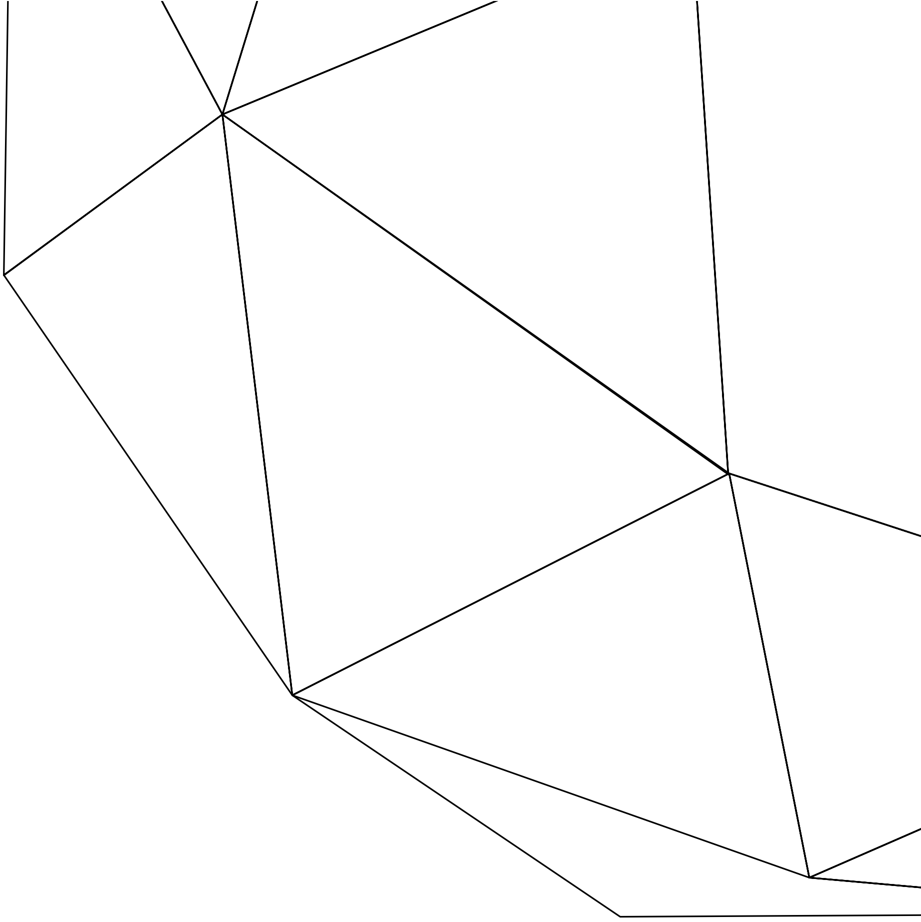

Climate-adapted project pipelines

How to financially incentivise well-designed climate projects

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GREEN CLIMATE FUND, April 2024

Contents

I. Existing challenges in climate-resilient infrastructure finance

This position paper aims to provide input to the Chapter on Finance of the Biennial Report on Global Infrastructure Resilience. The Chapter defines several problems and possible solutions to streamline finance for climate-resilient infrastructure. As a contribution to that Chapter, this paper focuses on respective challenges to the broader finance mobilisation for climate-based projects. This document pays particular attention to integrated and sequenced project pipelines as the solution for crowding in funds at an unattainable scale for a single asset.

The challenges this document focuses on and provides suggested solutions for are summarized below:

- **Insufficient infrastructure governance to be fostered by developing integrated multi-project pipelines for multi-year budgeting and systematic dialogue with potential financing partners.** In the case of interventions focused on adaptation to climate change, this also means encouraging the public sector to enable access to the climate data necessary for project structuring.
- **Incomplete economic analysis conducted of proposed economic benefits to determine true project impact.** Analyses should include avoided losses achieved by higher climate resilience of settlements, subsequent gains in business continuity, and diminishing debt burdens for countries, regions, and cities. Whenever possible, eco-systems-based adaptation should be encouraged, and its benefits should be monetised. Nature-based solutions' benefits range from a healthier environment, biodiversity, and food security to avoided emissions from preventing built infrastructure.

  Each additional benefit translates to a higher economic value represented by improved Economic Net Present Value and better Economic Internal Rate of Return. The higher value of these ratios, the more significant the positive social, economic, and environmental impact. Therefore, project promoters that structure their projects with due concern for the climate-related benefits of their endeavours should be rewarded with cheaper capital, favourable financing terms, and tax incentives. Private sector investors should be especially encouraged as they can play a pivotal role in filling the existing financial gap. In the case of well-structured impactful project pipelines, private institutional investors can also be encouraged by commensurate de-risking facilities provided by the public sector.
- **Inadequate consideration of physical climate risks in financial valuations of projects.** Current financial ratios do not incentivise an integrated approach to climate resilience. This should change as a cohesive approach enables avoidance of sequenced infrastructure failures and allow for smart project sequencing (prioritisation of critical infrastructure for livelihoods and business continuity). Changing the approach will enable financing partners to promote projects with a higher impact at a lower cost throughout the project life cycle.

II. The position paper goal and structure

2.1 Main Goal

Concerning the challenges defined above, this paper discusses the advantages of climate science-based project pipelines. This document also discusses how site-specific climate vulnerability analysis enables the definition of interrelations among infrastructure assets and surrounding ecosystems. This integrated approach refrains from a domino effect of failures and broader losses. Such characteristics deserve a much lower risk ratio and commensurate financial remuneration or incentives.

The IPCC AR6 WGII report proposes “transformational adaptation”, defined as changing the fundamental attributes of a social-ecological system to address the root causes of vulnerability as opposed to “incremental adaptation”. Alongside this conclusion of the IPCC, this position paper discusses the potential advantages of climate-science-based integrated project pipelines (as opposed to single adaptation projects) that may provide climate-adaptation synergies and systemically diminish project risks. Well-designed and managed project pipelines are also powerful governance tools to be used by public sector leaders.

Why project pipelines are important?

Project pipelines are important because they provide a forward (and backward) view of planned investment, enabling government, industry, and communities to better plan and prepare for infrastructure development.

- Pipeline development is an essential step in planning infrastructure for **governments** that complements the government's infrastructure plans and project preparation practices.
- **Industry** needs pipelines to plan and prepare its resources both on a micro level (in pursuit of specific programmes and projects) and a macro level (by using pipelines to identify market trends). Pipelines are also an important resource for attracting new entrants to infrastructure markets and for industry and academia to prioritise workforce education and upskilling programmes.
- **Communities** want pipelines so that they can see what is being built and when. Pipelines can be an effective tool to demonstrate transparency and build trust with communities.

Source: Based on Global Infrastructure Hub

2.2 The structure of the document

To present the advantages of creating climate-based project pipelines, this position paper presents a list of selected projects’ risks and the process of creating the project pipeline, including the impact such a process has on mitigating risks, including climate-related threats.

From a technical point of view, well-structured projects should limit the extent of possible risks in both implementation and operation. In the case of adaptation to climate change, risk mitigation for integrated and sequenced activities is superior to that possible when investing in single assets.

Consequently, each step of the project pipeline creation has a specific paragraph presenting the achieved mitigation effect regarding project risk.

Sustainable investors look for projects that positively impact people, settlements, the environment, and macroeconomic stability. Valuing such positive effects means bringing cheaper funds and prioritising projects with higher positive impact. To present the advantages projects bring to the overall society and environment, the benefits need to be presented and assessed against existing costs. Such a comparison exercise is conducted under economic analyses of projects.

To present the advantages of project pipelines over single projects, each step of the project pipeline development presented below is accompanied by a paragraph that can constitute an entry point for economic analyses.

It is also important to underline that this paper presents a methodological approach that leads from climate science to an integrated and sequenced project pipeline only to the level of project concepts. The final steps of preparation of the robust documentation for each project is not covered by this document.

III. Climate hazards and project risks

3.1 Project Risks in Financial Valuation

In most cases, the valuation of project risks in financial analyses is calculated under solvency analyses. The ability of the project promotor to repay mobilised funds is a common element in consideration of risk and the main link between project risk and the cost of capital. The higher the risk, the more significant the negative impact on repayment ability and the higher cost of capital. The ability to repay is reflected in cash flow analyses as a debt-service cover ratio (DSCR). Even though the debt is used in the name of the ratio, it is employed for any funds that need to be repaid.

However, behind the DCSR, no coherent project risk assessment guidance is agreed upon among financial partners that will systematically encourage improvement in project quality. Consequently, the role of project pipelines in enabling further reduction of risks compared to the single-assets approach is insufficiently recognised, especially in the climate change context. This paper discusses the creation of a more systemic approach to translate project pipelines' ability to diminish risk into more favourable financing.

This paper may serve as a starting point for further discussion of a better valuation of the advantages of well-structured and sequenced project pipelines and remuneration in the form of financial incentives.

To present the potential of project pipelines to decrease risk, the following list of project risks is selected:

- **Construction risk**: Most commonly encompassing cost overruns and difficulty in achieving expected project performance at the scheduled time.
- **Technology risk**: While often presented as part of construction risk, today, with unprecedented climate threats and fast-paced technological advancements, we must look at technology risk separately. This paper defines technology risk as the possible adverse effects of introducing unknown technology to a market. Adverse effects may encompass both technical problems as well as unplanned financial costs.
- **Cost/revenue risks**: Cost risks include any cost overrun from sources other than construction risk. Revenue risks are observed whenever revenues fall below an expected minimum level.
- **Market risks** in this document focus on market failures, also called market gaps, threatening the project's successful implementation and maintenance. Such market failures can be related to any aspect of the project development, performance, or result. An adequate list of market failures must be defined for each specific circumstance. Among the most common market failures are the following:
    - Insufficient technical capacity;
    - Costly access to services and equipment–especially in the case of Small Island Developing States (SIDS), exacerbated by distances in the case of Pacific States;
    - Stringent land ownership regulations disabling effective infrastructure investments;
    - Insufficient demand for new solutions resulting from limited awareness (e.g. not incentivising efficient use of energy or water, leading to waste and overuse); and
    - Limited access to insurance.

All market failures related to project development, implementation and operations must be duly identified, analysed, and addressed to mitigate their potential adverse effects.

- **Natural resources/ supply risk**: This risk category is essential, specifically in the context of climate change. Climate adverse effects stretch the supply of natural resources like water, sand, and healthy ecosystems. They can severely affect project deliverables in cases where project outputs heavily depend on endangered natural resources. One of the most pronounced problems is increasing water scarcity which can directly impact the effectiveness of hydropower production or irrigation systems.

- **Operating and maintenance risk (O&M):** Related to the quality of management of assets or networks, specific market failures relating only to O&M should be defined more precisely based on project characteristics.
- **Political/regulatory risks**: mainly recount changes in the country or regional development policies and priorities, often due to government changes. This risk also refers to unfavourable regulations jeopardising project implementation, maintenance or costs related to these processes (e.g. increased taxation).
- **Macroeconomic risks:** Severe deterioration of the country's macroeconomic profile resulting from the impact of climate hazards, macroeconomic risks are most prominent in SIDS countries, where each hurricane or cyclone may directly impact the country's debt profile and disable overall value chains (e.g., energy supply to the country).
- **Documentation risk/engineering risk:** Related to the overall robustness and consistency of project documentation, understanding documentation/engineering risk is a prerequisite for effective implementation, construction, and management.

3.2 Climate hazards and their translation to project risks

A climate or natural hazard may cause loss of life, injury, or other health impacts, damage and loss of property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

Climate hazards are divided into acute hazards and chronic hazards. Acute hazards include extreme weather events like storms or heatwaves and cause climate disasters like floods, landslides, droughts, and wildfires. The second climate hazard group, chronic hazards, is characterised by prolonged onset, which includes rising sea levels, increasing temperatures, or changing rain patterns. Natural hazards, often combined with climate hazards, are related to seismic activities and result in earthquakes, tsunamis, and volcanic eruptions.

The best analytical approach to translate climate and other natural hazards into project risks is to use vulnerability analyses based on existing studies and literature, including the IPCC report. Going from **exposure** of people and assets to hazards to **sensitivity** to hazards (possibility of adverse impacts) and **adaptive capacity** to hazards (existing capacity to mitigate adverse impacts) allows for an assignment of vulnerability levels. This exercise enables the translation of climate and natural hazards into project structuring elements and, consequently, to the assignment of project risks.

This correlation is presented in section VI of this document on a more granular level.

IV. Economic analyses

Commonly conducted economic analyses are related purely to developmental effects, mainly achieving sustainable development goals. These typical analyses do not consider the benefits from avoided losses and damages induced by climate change, the continuation of services delivered by resilient infrastructure, or additional benefits resulting from deploying nature-based solutions instead of high-emitting hard infrastructure. Consequently, economic indicators like the Economic Net Present Value do not capture the spectrum of gains for social and economic development provided by well-designed climate projects. Organisations like the Asian Development Bank and the Green Climate Fund have begun to promote climate-related externalities in economic analyses.

However, there is still no attempt to capture the benefits of an integrated approach to project pipelines focused on adaptation to climate change.

This document intends to encourage such practices. To this end, methodological steps presented in section VI are accompanied by a preliminary evaluation of their role in defining more robust economic analyses.

V. Limitations of the research behind this position paper

1. As previously presented, the debt service cover ratio, based on project risks, is an indicator for assigning the cost of capital. In other words, quantifying project risks defines the cost of funds (e.g., level of interest rates or risk premium). However, the quantification of risks is based on an expert's judgment and consequently, calculating the cost of capital is subjective and often unclear to many project promoters. Thus, this paper aims to discuss standard quantification for risk mitigation and systemic financial rewarding of project quality.
2. Most currently tested innovations in the valuation of climate-adapted project performance look at:
    - Single assets, not project pipelines based on the systemic approach to interlinked infrastructure (linear or territorial), or
    - Developmental projects incorporating physical climate risks if these are a substantial threat to the asset performance (e.g., raising heat impact on power plant cooling capacity).

    However, an integrated approach to investments tested in the case of developmental projects (e.g., integrated territorial investments successfully implemented throughout the European Union) present the superiority of performance and benefits of projects from integrated project pipelines. In adaptation to climate change, sequenced infrastructure failures are observed around the globe because of climate hazards' adverse effects. Thus, a solid technical justification exists for assuming that an integrated approach will substantially lower most climate project risks and strengthen other developmental benefits.
3. The capacity of ecosystems to act as blue or green infrastructure that replaces grey solutions is still to be assessed. Consequently, there is only fragmented evidence in this respect. Therefore, nature-based solutions (NbS) are suggested in this paper for further assessment but not proposed as tested options.
4. Most economic analyses, used here interchangeably with cost-benefit studies (CBA), list benefits and costs from the developmental perspective. More advanced approaches, like the ADB 'Analysis of Climate-proofing Investment Projects' and GCF 'Economic and Financial Analyses (EFA) Guidance', Annex VI to the GCF 'Appraisal Guidance', discuss the benefits of climate-proofing activities and introduce ancillary benefits of climate-adaptive solutions but there is no systematically developed list of climate-based project costs and benefits. The creation of mutually agreed upon climate-related expenses and benefits and their monetisation would help justify of the positive impact of adaptation to climate projects. Furthermore, the economic analyses for adaptation to climate change projects should enable cross-sectoral, integrated valuation. Currently, existing solutions are mainly sector-based, promoting benefits and costs calculation specific to one sector, e.g., waste management, transport, and health.

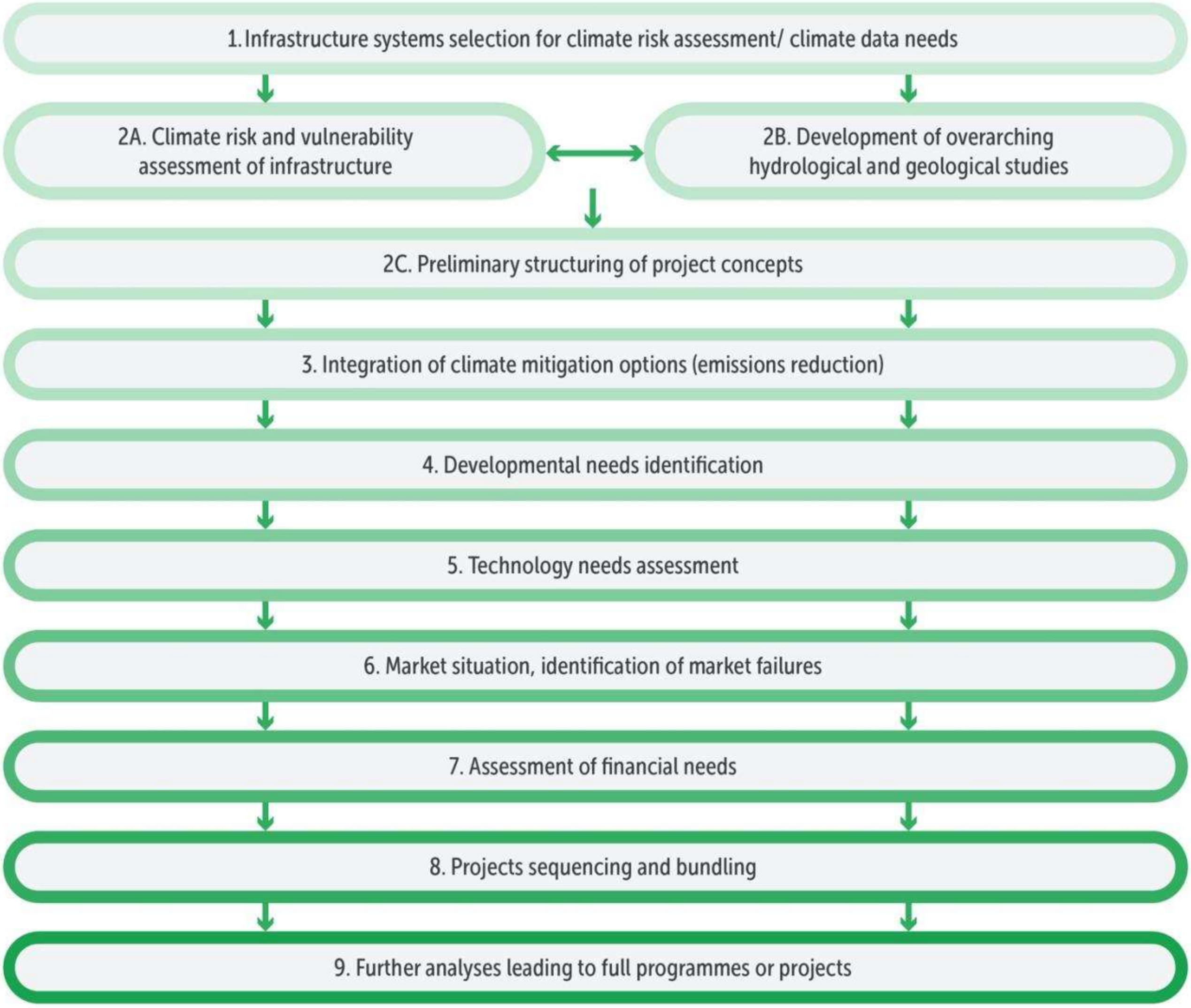
    The integrated approach to economic analyses, resulting from systemic climate analyses and leading to several linked interventions through infrastructure and ecosystems, is tested by the Green Climate Fund under the pioneering methodology developed with the Jamaican Stakeholders and Oxford University - 'Jamaica Systemic Resilience Assessment Tool (J-SRAT) and hybrid projects pipeline structuring methodology with the deployment of Nature-based Solution', called 'the Jamaica Pilot'. This effort's results will be ready in the second half of 2023 and will be translated into a more generic methodology for replication in any jurisdiction.

VI. Climate-adapted project pipelines

The methodology for the integrated project concept pipeline proposed in this document builds on the analyses of De Connick et al. (2018), Noble et al. (2014) and Ley et al. (2022), who propose assessing adaptation options across six dimensions of economic, technological, institutional, social, environmental, and geophysical feasibility. Analysis of the feasibility of each of these adaptation options and their potential for risk mitigation co-benefits is summarised by Ley et al. (2022). The six dimensions present an analytical scope for selecting climate-adapted projects and thus provide a good starting point for understanding the contours of a good-quality adaptation project.

The methodology below further develops the six dimensions into nine subsequent analytical steps showing how integrated project pipelines could further strengthen project quality.

A diagram representing the integrated methodology to create project concept pipelines is shown below:



Until step 6, the project concept pipeline looks at quality boosting, risk mitigation, and economic value assessment. Future analyses may indicate additional steps or changes to this initial methodology.

Under steps 7 and 8, information gathered under steps 1-6 translates into financial needs assessment and potential structures definition to facilitate crowding in additional finance. Step 9 describes how information gathered under steps 1-8 helps structure high-quality technical assistance terms of reference that lead to the final project proposal.

1. Defining infrastructure systems to conduct a climate risk assessment and define climate data needs

1. Infrastructure systems selection for climate risk assessment/ climate data needs

1.1. Description of the step

Step 1 sets the scope for the overall analyses leading to the project concept pipeline. A functional area of interrelated infrastructure and surrounding ecosystems must be defined to achieve this goal.

A review of existing literature on infrastructure and surrounding eco-system, assets damages, service disruption, life loss and injuries is the best starting point to outline the most recommended systemic approach. Secondly, interconnections among infrastructure assets, economic activities, and social services must also be ascertained. Sequenced failures within past events resulting from characteristics of assets and their cross-dependence must be observed. These analyses should define the area for intervention (also called a functional area).

The next step is to cross-check the findings with existing developmental plans and ongoing and planned investments within the functional area. The complementary system approach or the functional area description can take many forms. The list below presents just a few options:

- Systems of infrastructure (*e.g., energy, transport, water*)
- Intersections of infrastructure systems (*e.g., energy for water pumping or sewage treatment*)
- Sectors dependent on infrastructure services (*e.g., fresh water for tourism, energy for the industrial zone, and infrastructure servicing the health sector*)
- Systems of critical infrastructure that cannot go ‘off-line’ in case of climate catastrophe (*e.g., selected shelters, hospitals, storage, emergency management buildings and interlinking roads, energy, and water infrastructure*).

Once the scope is narrowed to a specific system, broader research on climate data availability should be launched. The selection of climate data should cover the root causes of observed damages, losses, or service disruption in the functional area. In addition, analyses of future changes in the observed hazards’ scope, range and strength will enable appropriate solutions to be designed. In most cases, multiple climate hazards need to be considered. Natural hazards like earthquakes can further exacerbate the risk caused by climate hazards observed. All these factors must be addressed in conjunction to create site-specific resilient solutions.

1.2. Project risk mitigation

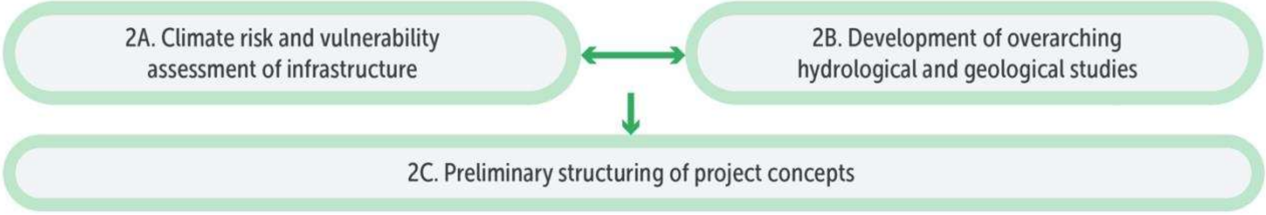
This step is also a preparatory phase for the vulnerability analysis, and thus mitigation of project risks will be presented within the vulnerability assessment section. This initial step has the potential to directly mitigate several risks, including cost/revenue risk, market risk, natural resources/supply risk, political/regulatory risk, and documentation risk.

A well-delineated functional area, with infrastructure and accompanying ecosystems, is a cornerstone of project risk mitigation.

1.3. Potential links to economic analyses

Information gathered at this stage constitutes the background for future cost-benefit analysis. Analyses of climate and natural disaster susceptibility, the vulnerability of communities, built-in and natural asset density, and previously observed losses and damages are starting points to define the benefits of the proposed actions.

2. Climate risk and vulnerability assessment of infrastructure and the development of overarching hydrological and geological studies



2.1. Description of the step

Vulnerability assessments reveal the most vulnerable geographic areas to climate and natural disasters. For infrastructure systems, the most common approach is the layering of maps that visually present hazard stressors and infrastructure networks, assets and surrounding ecosystems (presented in the previous section). In addition, the attribution of service disruption costs, human settlement refurbishment, economic activity interruption, and other social costs, primarily related to the most vulnerable groups, should be understood. This layering exercise provides information on the level of exposure of people and assets to climate and natural hazards. It is advisable to integrate eco-system maps as an additional layer. This integration of maps leads to the visualisation of the interaction of nature with endangered infrastructure systems. Consequently, nature-based solutions can be implemented to protect built-in structures and enhance natural resources supply.

Areas with the highest cumulation of risk factors illustrated with information layering are deemed the most vulnerable. In other words, these places are hot spots that need climate-proofing solutions and natural disaster protection.

Pilot initiatives demonstrating how to structure such information can be replicated and confirm that even if data is fragmented or available at low resolutions, targeted additional data gathering, modelling, and expert judgments can be added to conduct a site-specific, system-based vulnerability assessment successfully.

Examples of factors that assist in the determination of the vulnerability of people are presented below:

Demographics: Population density, % of disabled individuals in the community, % population under five years old and % population over 65

Human development: child malnutrition, malaria incidence, access to clean water, literacy rate, % Population 6-14 years attending school.

Income: per capita income, % of households earning less than the median income, % of families under the poverty line,

Employment: which sectors do they work in? In a rural area, what's the land tenure regime? Often the interest is in finding out % the employed in climate-sensitive sectors (rainfed agriculture, farming, fishing, mining, forestry).

Housing type: % of households living in informal settlements

Gender: % female population, % female-headed households

Economic variables: infrastructure poverty, %Crop land, % of cultivated land which is rainfed, % of agriculture in total GVA

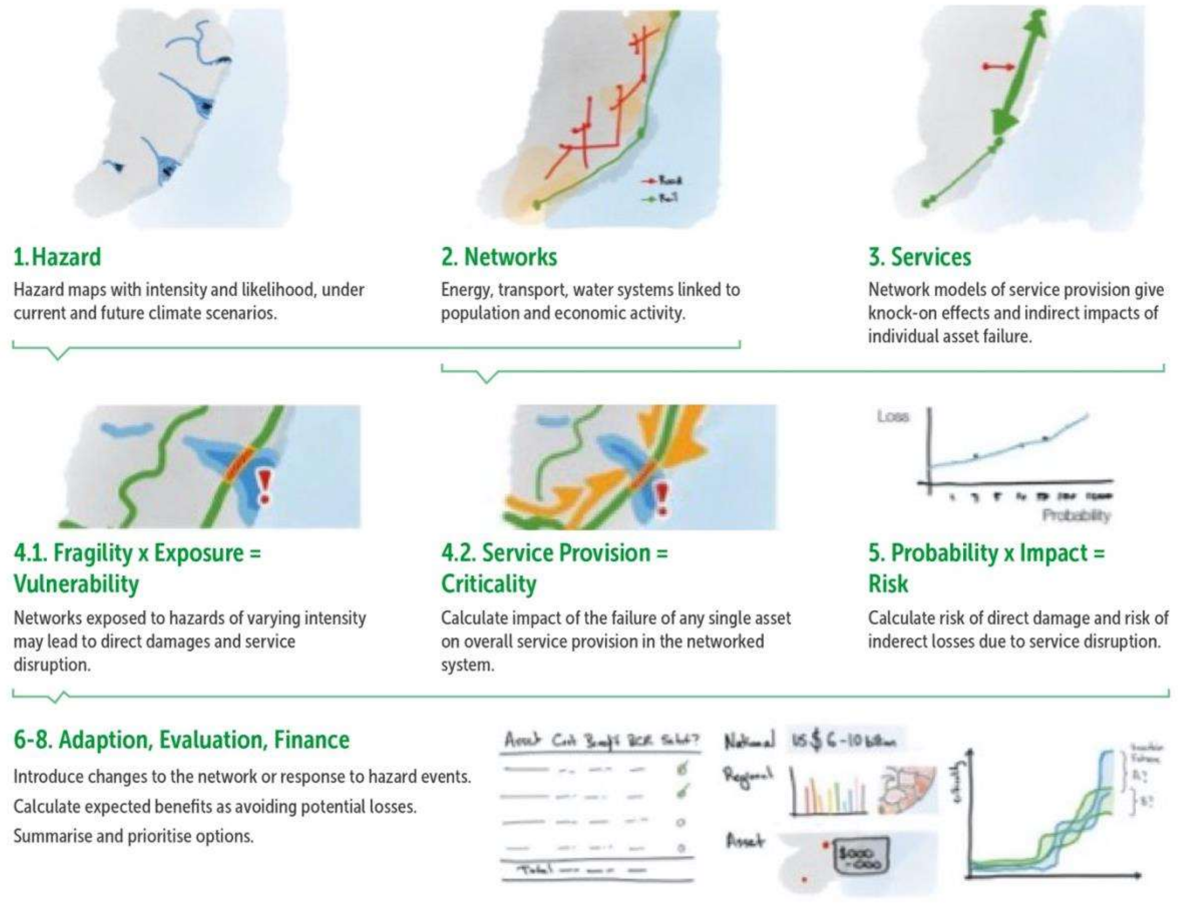
Source: IPCC Report, 2004

Examples of multi-hazard risk assessment solutions

The most efficient way to capture the vulnerability of people and assets is to structure and design methodologies or tools for continuous planning, project conceptualisation, and additional data gathering.

The examples presented below capture the two approaches tested in different parts of the globe. Both examples are at the advanced development stage and are ready for replication. Nonetheless, it should be noted that, as with any pilot approach, further refinements and country or region adjustments would be necessary. It does not differ from any other methodology that becomes more robust and detailed with more use and adjustments.

Example 1: Jamaica Systemic Risk Assessment



1. Hazard

Hazard maps with intensity and likelihood, under current and future climate scenarios.

2. Networks

Energy, transport, water systems linked to population and economic activity.

3. Services

Network models of service provision give knock-on effects and indirect impacts of individual asset failure.

4.1. Fragility x Exposure = Vulnerability

Networks exposed to hazards of varying intensity may lead to direct damages and service disruption.

4.2. Service Provision = Criticality

Calculate impact of the failure of any single asset on overall service provision in the networked system.

5. Probability x Impact = Risk

Calculate risk of direct damage and risk of inderect losses due to service disruption.

6-8. Adaption, Evaluation, Finance

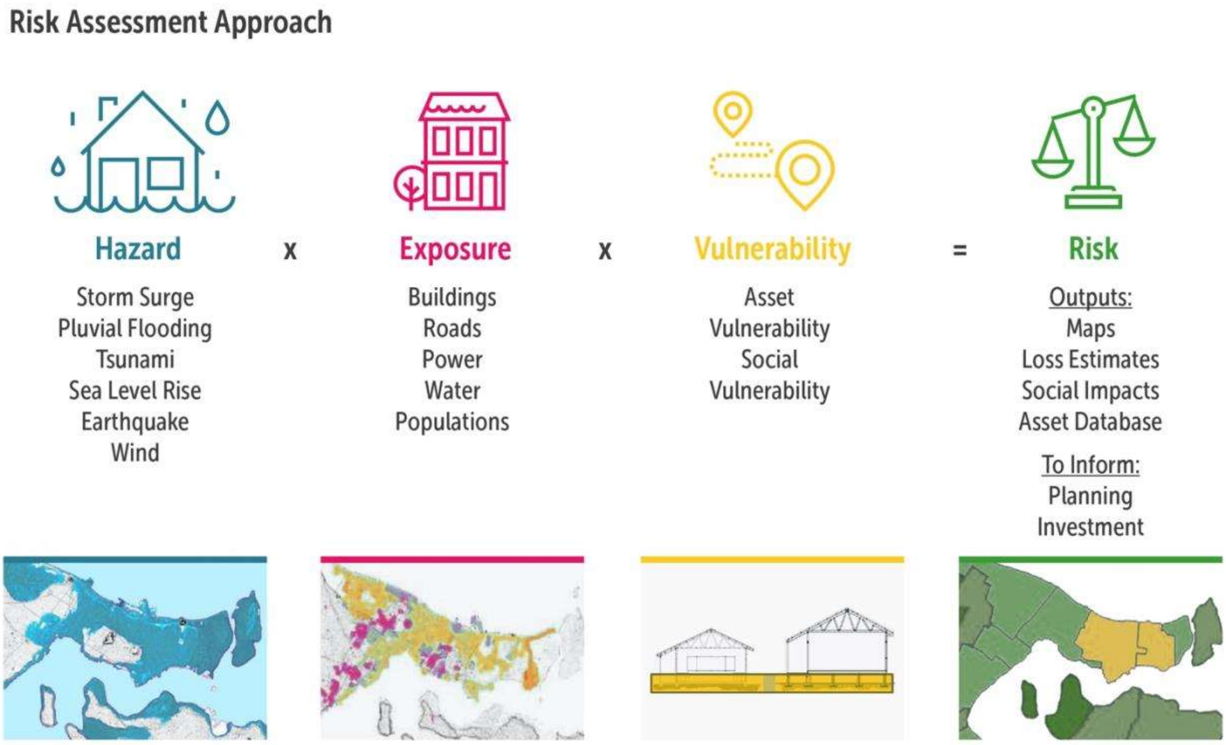
Introduce changes to the network or response to hazard events.

Calculate expected benefits as avoiding potential losses.

Summarise and prioritise options.

Source: Oxford University

Example 2: Tongatapu Multi-hazard Risk Assessment (ADB)



Source: Asian Development Bank

As presented above, multi-hazard analyses, which demonstrate characteristics of the climate or natural hazards' impact on a defined area, are essential for conducting further project concept pipeline analyses. However, such tools and methods capture only the general topography of the given territory. To fully grasp the vulnerability of different areas, **geological and hydrological studies** must be conducted. Since such analyses are resource intensive, there is a tendency to conduct geological and hydrological studies much later at the single project level. Consequently, project promoters try to narrow the scope, leading to fragmented and even subjective assessments and a substantial increase in all project risks.

Conducting geological and hydrological studies with vulnerability analyses is strongly recommended when additional information layering can still serve to identify more efficient interventions. Strategic documentation like National Adaptation Plans - NAPs (with substantial funding for these documents) can deploy such analytical approaches to inform high-quality future investments. In addition, many international organisations and multilateral development banks and funds provide technical assistance that can be used for blended vulnerability, geological and hydrologic assessments. These will serve many projects, not just one, and can become a background for systematic project pipeline generation and multi-year budgeting. Such an approach would also attract more international finance. Projects will be much better interlinked and grounded in territory-specific features, including natural resource capacity and characteristics (e.g., site-specific water cycle).

CASE STUDY The Functional Area of The River Basin: vulnerability analyses with geological and hydrological studies leading to a substantially reshaped project pipeline, diminishing project risks

Suppose historical data and the most convincing predictions present a substantial risk of exhaustion of freshwater resources in a specific functional area. In that case, the vulnerability analysis should start with a thorough examination of the availability of water resources for several decades into the future. Specific geological and hydrological studies can define the demand against water recharging capacity. Development needs assessments, and climate change prognoses should be part of this exercise. If current developmental patterns combined with climate change may result in water resource exhaustion, a paradigm-shifting change in the overall water system management should be undertaken. Consequently, a substantially reshaped and differently sequenced project concept pipeline should be proposed.

The first two boxes below present the business-as-usual scenario in which vulnerability analyses, as well as geological and hydrological studies, are NOT developed to serve an integrated approach to the systemic intervention conceptualisation:

A typical list of interventions proposed for finance related to the same river basin in isolation:

- climate resilient agriculture project (irrigation schemes)
- fresh water for urban area, including pumping from freshwater resources
- raising the capacity of the hydropower plant to meet net-zero emissions targets
- eco-systems restoration project

Projects are proposed by the administration from different sectors with a very limited co-ordination. Consequently, project promotors develop climate-proofing, hydrological, geological studies for each project separately.

Problems inherited from the development of projects in the presented fragmented manner:

- implementation problems, construction cost overrun
- underperformance of infrastructure resulting from water scarcity
- losses in food production
- losses in energy production
- local communities' unrest resulting from the presented disruptions in services provision
  deterioration of the macroeconomic situation of the region or even the whole country

The visualisation and explanations provided below present systemic climate hazard assessment combined with additional hydrological and geological studies for the river catchment area, which result in a change in the types and sequencing of projects:

A systemic climate risk assessment, vulnerability analyses, hydro- and geo-analyses are conducted on a functional area of the river basin to determine the most critical vulnerabilities:

- The same river catchment area covers three countries.
- Severe risk of maladaptation resulting from an increase in water extraction is observed.
- Deteriorating hydrological situation (e.g., insufficient water re-charging resulting from developmental activities) is present.
- Unfavourable geological structure limits water preservation and facilitates water run-off.
- There is no integrated approach to water management encompassing the three countries.
- Future climate projections present a convincing information regarding prolonged droughts periods, shorter rainy seasons and growing saltwater intrusion to fresh water aquifers resulting from sea level raise.

Joint systemic climate risk assessment, vulnerability analyses, hydro- and geo-analyses lead to a redefinition of project pipeline. The new sequencing of projects reflects a need to enable aquifers recharging and better water management:

- Integrated water management plan for the whole river basin covering three countries.
- Wastewater treatment and water-reuse programme for the metropolitan area.
- Aquifers recharging, wetlands preservation, eco-systems restoration integrated programme (multi-projects programmatic approach for three countries).
- Agriculture project focused on water re-use and harvesting, new boreholes carefully assessed based on the overall watershed capacity, and water needs of other uses.
- Resilience-based energy mix analyses are to be conducted to decide on the future available capacity of hydro-energy to be produced, in conjunction to other needs regarding water usage.
- Small-scale renewable energy projects to be defined during as part of the energy transition with possible facing out of hydro-energy.
- Locally led eco-system management project to preserve existing eco-systems in the watershed. and foster water recharging, purification, and preservation.

2.2. Project risk mitigation

A list of project risks and their mitigation is based on the case study developed in the previous paragraph. A careful analysis of the river catchment area shows a high supply/natural resources risk. This starting point resulted in a paradigm shift in the projects' pipeline definition. An important focus is on sequencing projects in a way that prioritises water management and freshwater protection activities. Consequently, a transformational decrease in all the other project risks (construction, technology, revenue, operations, and maintenance risks) can be achieved.

A substantial decrease in macroeconomic risk for the city or region should be observed due to this paradigm-shifting change. A detailed description of risk mitigation is presented in the table below:

Risk	Risk mitigation factors to be valued in the cost of capital
Construction risk	Minimised in a transformational way by: • Changing subjects for future engineering design (reshaped project concept pipeline); • Selection of projects that mitigate paramount risks of water exhaustion • Integrated information about climate and natural hazards, and related vulnerability of people, assets, and nature; and • Provision of geological and hydrological studies informing the future design of interrelated projects.
Technology risk	Decrease in a transformational manner by providing feasible projects with clear information on interrelation among activities. In addition, the integrated analyses can provide information on the limitation of existing technologies and technical solutions to protect existing infrastructure successfully (e.g., Tongatapu Multi-hazards Risk Analyses). Consequently, replacing human settlements and accompanying infrastructure may be suggested before any engineering study is conducted.
Cost/revenue risk	Both costs and revenue risks are addressed in a transformational manner allowing for the selection of interventions that can bring expected results throughout the infrastructure life cycle.
Natural resources/supply risks	This risk (water scarcity) is substantially diminished. In addition, the careful assessment of this risk from a climate change perspective transforms the whole project's pipeline.
Operating and maintenance risk	The proposed approach substantially limits O&M risk by preventing a cascading effect of construction, technology, cost, and revenue risks from adversely impacting operations and maintenance activities.
Political/regulatory risks	Public sector ownership and leadership of the steps presented in this section substantially diminish perceived political risks.

	The leading role of the public authority also enables analyses of regulatory aspects to determine necessary regulatory changes. Thus this can be the most effective starting point to reduce additional regulatory risks.
Macroeconomic risk	If the analysed geographical area represents a substantial cumulation of GDP and if the financing of the project pipeline relies heavily on public debt, infrastructure and ecosystems losses avoided and business continuity can have a tremendous positive impact on macroeconomic indicators.
Documentation/ engineering risks	This risk is also addressed in a transformational manner due to the limitation of construction and technology risks.

2.3. Potential links to economic analyses

The vulnerability assessment, supported by earth structure and other studies, is the best starting point to define costs and benefits that should be analysed for the project concept pipeline. In addition to typical developmental costs and benefits, specific climate and natural hazard costs and benefits should be noted to present a complete list of advantages to capture in the Economic Net Present Value (NPV) and Economic Internal Rate of Return (EIRR).

A non-exhaustive list of potential additional benefits that can be quantified at this stage of the methodological advancement are the following:

- Avoided costs of natural resources depletion,
- Value of avoided losses and damages,
- Value of additional eco-systems services,
- Avoided emissions and additional emissions sequestration provided by selected solutions, and
- Value of avoided operation and maintenance costs.

3. Integration of climate mitigation options (emissions reductions)

3. Integration of climate mitigation options (emissions reduction)

3.1. Description of the step

With a narrowing window of opportunity to slow down global warming, it has become crucial to use any opportunity to reduce emissions using energy-efficient solutions and to introduce additional emission sequestration options.

The preliminary list of integrated project concepts from the previous analytical step provides the most opportune tool to cross-check how to reduce emissions further. This requires expert judgements to determine appropriate measures for selected interventions. Some examples are listed below:

- Selection of energy-efficient features for refurbishment of the existing building stock and design of newly built structures,
- Installation of renewable energy engines,
- Exploration of green solutions as alternatives for hard infrastructure (i.e., avoiding highly emitting production of infrastructure components, preventing emissions resulting from

transport and installation of infrastructure, additional sequestration of emissions by natural habitats) and

- Use of low-emitting transport solutions during the project's implementation, operation and maintenance phases.
- However, it must be emphasised that careful engineering design is necessary to ensure that climate-resilient and emission-reducing solutions do not contradict each other (e.g. energy efficiency solutions should not diminish the structure's resilience against wind impact or wind shear effect, climate-proofing of roofs should envisage loads resulting from solar panels).

3.2. Project risk mitigation

The main gain can be presented for cost/revenue and regulatory risks. With a global shift incentivising low-emission solutions and rising costs of high-emitting energy generation and technologies, low-emission options are less risky. In addition, there is a rising global trend of refusing concessions for fossil fuel extraction if this raises environmental concerns. Therefore, long-living infrastructure independent from coal or oil is more sustainable mid-and long-term.

Finally, many climate financial resources are unavailable if emission-intensive fossil fuels are promoted throughout the project value chain. A strict approach to this matter is present in the financing policies of several multilateral organisations, and the trend is rising.

3.3. Potential links to economic analyses

Significant benefits that should be underlined are rooted in emission reductions and avoiding fossil fuel dependency.

4. Developmental needs identification

4. Developmental needs identification

4.1. Description of the step

As presented at the beginning of this document, the proposed methodology tries to capture situations in which the severity of climate hazards may force change in the development pathway. However, developmental aspects like food security, fresh water supply, waste management, water sanitation, energy access, and accessible transport are still paramount. In other words, achieving developmental goals stays crucial, but investment generation starts from the systemic climate risks assessment.

Crucial interdependencies of climate-proofing and developmental activities should be defined at this stage. Examples of such interdependencies are provided below:

- Refurbished or newly structured anti-flooding infrastructure efficiency is possible only with the integration of waste management activities to avoid heavy waste blockages in drainage passages;
- Capacity of coastal eco-systems to diminish the impact of tidal waves requires assurance that toxic substances do not jeopardise the quality of these eco-systems, and
- Resilience of infrastructure assets needs to be secured by land development plans (e.g. public ownership of land ensuring sufficient space for resilient infrastructure development, necessary space for drainage and surface water purification)

4.2. Project risk mitigation

The careful consideration of interrelated developmental aspects throughout the analyses results in additional mitigation of several risks, including construction, cost/revenue, and operation and management risks.

4.3. Potential links to economic analyses

As many organisations practise, all developmental aspects should be presented in the cost and benefit analyses.

Suppose additional developmental activity is included to mitigate adverse impacts of climate change or natural hazards (e.g., waste management for drainage performance). In that case, it should be quantified and incorporated into the cost and benefit analyses.

5. Technology needs assessment

5. Technology needs assessment

5.1. Description of the step

There are two main definitions of "technology transfers". The first relates to the innovation process when a new technology is transferred from the laboratory to the industry for a pilot phase and ultimately to a production line. The second technology transfer process involves moving existing technology to a new environment in another country. The two types of technology transfer may occur together and share similarities. The following aspects should be considered during the decision process about the introduction of new technology, preparation for its implementation, and cost calculation:

- Intellectual property (IP) rights and licensing include not only the cost of the license for a commensurate period but also the equally important cost and time for legal arrangements and negotiations. Highly specialised experts are essential to advise the best licensing rights to give sufficient access to spare parts, servicing, and know-how.
- Verification of local competencies to implement and manage new technology (more about local technical capacity is presented in the market failures section).
- Compatibility of the new technology with the broader interrelated infrastructure system, cost and time to introduce adjustments.
- Ability to ensure technology scalability to new projects if the technology proves its efficiency.

Technology needs assessment is a preparatory process that enables the preliminary evaluation of existing technologies on the market that can be responsive to the engineering needs of the project concept pipeline. Such assessment, conducted early when the pipeline is still at the concept stage, is indispensable to:

- Understand what technology transfer activities need to be undertaken during the project preparation phase, calculate related costs, and set realistic timelines (to be reflected in project sequencing);
- Reshape preliminary project concepts in case technology transfer is too costly or the regulatory environment is not yet conducive and needs substantial time to be transformed;
- Conduct counterfactual analyses of locally available solutions (e.g. ventilation of houses that substantially diminish wind shear effect and protect the structure from collapsing and roofs from being torn off);
- Analyse technology change impact on interrelated infrastructure systems/assets.

- Analyse the performance of the technology in the investigated area, considering climate, topography, geological and hydrological structure; and
- Define situations with no existing technology to ensure infrastructure integrity (e.g., the strength of the combined flooding effect of fluvial, rain, and wave tide cannot be addressed by any existing engineering solution). If there is no option to protect people and assets with existing technologies, the replacement of human settlement shall be discussed.

The assessment elements presented above do not constitute an exhaustive list. Selection of proper criteria for the technology transfer must be undertaken by experts encompassing existing climate and natural hazards impacts, as well as geological and hydrological characteristics of the functional area (e.g., a river basin).

5.2. Climate and project risk mitigation

Risk	**Risk mitigation factors to be valued in the cost of capital**
Construction risk	Limited by carefully selected technology that will work with the rest of the existing system and thorough assessment of necessary technical capacity for design and civil works (installation and O&M).
Technology risk	Fragmented technology transfer planning for single assets and underestimation of technology transfer costs are the main risk factors repeatedly occurring in climate projects. Presented factors can be substantially diminished by activities presented in section 5.1.
Cost/revenue/market risks	Robust analyses enable proper budgeting, assignment of revenue streams and mitigation of market failures. Presented factors can be substantially diminished by activities presented in section 5.1.
Natural resources/supply risks	Mitigated because of proper technology choices. Technology that can perform well under changing climate conditions and a high propensity for natural hazards.
Operating and maintenance risk	Substantially reduced by the assignment of adequate construction costs and robust life cycle costs for technology transfer and use. The risk is further decreased by careful assessment of natural resource availability.
Political/regulatory risks	Limited by technology transfer analyses that embrace the regulatory environment – to choose technologies that can work within the existing regulations. Alternatively, the public sector’s commitment to making the regulatory environment conducive to technology transfer and use will positively impact political and regulatory risk levels.
Macroeconomic risk	Appropriate technology solutions may positively impact macroeconomic indicators if the functional area or integrated system represents the substantial cumulation of GDP and financing of the projects pipeline relies heavily on public debt. A broader government policy to attract effective and innovative technologies will also result in market stimulation, new jobs and GDP growth.

Documentation/ engineering risks	Addressed in a transformational manner due to selecting feasible technology solutions to inform future studies.

5.3. Potential links to economic analyses

A presented integrated approach, with a well-delineated functional area and appropriate diagnosis of the situation, allow for a clear and convincing presentation of the benefits of the proposed approach from the social, economic and natural resources perspective. Specific technology transfer-related benefits may be defined and monetised.

6. Market situation, identification of market failures

6.1. Description of the step and its relation to project risks

Following the EU Ex-ante Assessment for Financial Instruments Guidance: “The concept of market failure refers to non-functioning aspects of the market which result in an inefficient allocation of resources and entail the underproduction or overproduction of specific goods and services”. Each market failure that can adversely affect project design, implementation, operation, and maintenance constitutes a substantial risk for the project.

Market deficiencies not captured and addressed under the project preparation phase translate into construction risk, increase costs and result in underperformance of infrastructure, leading to the revenue decline.

The best moment to address existing market failures is when the project concept pipeline is being developed. Market failures need substantial time to be addressed. Therefore, it is also more effective to introduce systemic solutions to address market failures at this stage (e.g. market awareness campaigns or technical capacity training bundled under special technical assistance packages).

Many market analytical approaches present lists of crucial market failures that must be assessed depending on project characteristics. Manuals (Annexes) to the EU Ex-ante Assessment for Financial Instruments are an excellent example of such catalogues, presenting, *inter alia*, lists of potential market failures related to emissions reduction or urban and territorial investments.

Among the most crucial market failures that are decisive for successful results of interventions is the capacity to design, implement and finance project concept pipelines. Well-structured capacity assessment allows for shaping meaningful technical assistance requests. Such exercises also enable the creation of project governance that fosters local capacity building (e.g. incorporating local entities as subsidiary partners to stimulate knowledge transition).

6.2. Climate and project risk mitigation

A good understanding of existing market failures and how to address them and assess feasible activities within a given market situation are indispensable parts of the intervention specification. If not appropriately addressed, every market failure translates to risk that can jeopardise the preparation, implementation or maintenance of results. Market failure typology allows defining which project risk they refer to e.g., high tax rates can translate into regulatory or revenues risks; lack of engineering capacity may result in poor procurement and inadequate documentation quality.

6.3. Potential links to economic analyses

Well-defined market failures and activities assigned to address these failures can result in additional benefits, e.g., the creation of the technical capacity of local entities and individuals, new jobs, and new services creation. In other cases, addressing market failures may further boost already defined benefits, e.g., freshwater provision for communities resulting from the creation of integrated water management and enhanced communities-based water management governance.

It is advisable to screen all identified market failures and ways these are mitigated by proposed measures from the perspective of additional economic benefits or enhancement of already identified benefits. Secondly, the additional positive outcome needs to be measured under the economic analyses.

7. Assessment of financial needs

7. Assessment of financial needs

Information gathered throughout the process presented in steps 1 to 6 permits the calculation of the required funding for the further development of the project concept pipeline to full project proposals. In addition, arriving at this stage of project concept pipeline readiness, it is possible to plan and budget additional activities that result from the enumeration of market failures and structuring of necessary mitigating actions.

As presented in section III, point 1, a substantial reduction of project risks allows for a better valuation of the cost of capital, expressed in the debt-service cover ratio. Moreover, analyses conducted until now provide a good understanding of the potential project implementation, operations, and management costs.

The methodological approach proposed in this paper defines infrastructure systems endangered by climate and natural hazards. Consequently, the project concept pipeline may encompass private and public sector projects. The methodology thus automatically indicates if the local private sector operations may be subject to adverse climate or natural hazards, indicating the potential interest of the public sector in resilience creation.

In case, the potential resilience-building intervention creates revenue streams, e.g., climate-proofing fresh water and sewage systems for an industrial area or tourist resort - that can be a preliminary indication for public-private partnerships.

Finally, a well-bundled project pipeline can attract private-sector institutional investors by issuing climate bonds.

With this background information, it is possible to conduct preliminary financial and economic analyses and understand how much public finance needs to be mobilised to co-finance projects or to provide de-risking solutions to incentivise potential private partners. In most cases, additional funds will be required over and above those available locally. Information gathered at this stage can help to attract external financial resources and set expected and well-justified levels of concessionality:

- Firstly, a high-quality project concept pipeline enables maximum technical de-risking of projects before financial engineering provides remaining risk mitigation to attract the private sector.
- Secondly, identification and monetisation of all additional economic benefits and reduction in economic costs will result in the high socio-economic performance of proposed project concepts. The higher the economic value of the project, the better financial conditions that international financial partners can offer, especially development and climate banks and funds.

8. Project sequencing and bundling

8. Projects sequencing and bundling

Stages 8 and 9 of this methodology are strongly interrelated and iterative. Thus, the cross-use of results of the emerging assessments is advisable.

Project sequencing is a multi-criteria exercise that defines when the development of complete project documentation and subsequent implementation of projects can happen. Many aspects need to be accounted for to sequence projects well. Analyses conducted under steps 1 to 7 provide vital information necessary to perform this exercise. A non-exhaustive list of the sequencing criteria is presented below:

- Criticality of the investment from the perspective of social services (e.g. functioning of the hospital);
- Criticality resulting from a high probability of sequenced failure that the asset/ system damage can cause;
- Criticality of the resource that is a driving force for the overall system (e.g. priority for freshwater supply and water recharging in case there is a high risk of water supply shortages);
- Interdependence of results (e.g. drainage enhancement conducted in parallel with waste management improvement when drainage capacity can be jeopardised by waste charge);
- Severity of market failures and time necessary to address the issues (e.g. introduction of new regulations, creation of specific new capacity of local engineers); and
- The level of finance and implementation capacity that is more conducive for specific projects from the pipeline to go first.

This multi-criteria sequencing analysis results have additional de-risking value as projects are implemented only when there is a conducive environment. The well-designed criteria for project sequencing allow for avoiding losses and damages since the most critical and feasible for implementation interventions are prioritised.

Another effective tool that enables intervention sequencing is related to engineering studies and sequencing of resilience creation for an asset or combination of interrelated assets, e.g., port resilience against sea level rise. This engineering analytical approach is commonly known as ‘real options analysis’. When investments are conducted under uncertain climate scenarios, the most efficient implementation approach can be to design more robust foundations for infrastructure with lighter upper layers (e.g. bridges, ports, and other coastal settlements) to enable further refurbishment in the future. Real option analyses are a design approach that allows for step-by-step enhancements depending on climate change observation. For example, the robust foundations engineering is based on the long-term most probable climate scenario. The upper layer is structured to create resilience only for the first 10-15 years. Suppose observed climate change during this time proves the proposed upper structure is insufficient or will soon reach its performance limits. In that case, it is refurbished, raising its resilience levels commensurate with the possible climate change in the future and based on lessons learnt from the past. Real-option analyses are a practical engineering tool that can lead to the efficient use of funds under unpredictable futures. It also allows for effectively monitoring the infrastructure performance and assigning potential refurbishment costs.

Asian Development Bank, in cooperation with Deltares, developed an approach called Adaptation Pathways. This multi-investment analysis method presents the pathways to resilience, where asset enhancement needs are foreseen from the outset and closely monitored. There are two thresholds envisaged. The first verging point is when the asset needs refurbishment to maintain its performance. The second verging point is reached when the solution becomes obsolete and needs replacement by a much more resilient structure.

It should be noted that infrastructure developed under real option analyses substantially delays the moment of infrastructure obsolescence, thus allowing for more efficient use of funds.

Project bundling is an informed decision of project grouping that maximises the ability to mobilise finance. It is of utmost importance to go through this exercise, ideally preceded by the analytical approach presented in previous steps, in order to decide what kind of financial solution can be structured to finance emerging projects effectively. Project characteristics are an essential pre-requisite to define the best funding structure and inform the use of different financial tools to maximise funding performance (e.g. debt, equity, mezzanine, grant, guarantee, technical assistance, or a combination of these tools). **The upfront setting of financial vehicles without thorough information on project attributes results in the underperformance of financial vehicles and the inability to find projects that fit prescribed financial mechanisms.**

Project bundling is also essential to understand possible layers of private finance engagement (three levels of private finance engagement presented in section 7). In other words, the blending of public and private funds.

Project bundling and the following selection of financial tools and their combination needs careful assessment from experts representing different technical skills: engineers, economists, lawyers, and financial experts. Three examples of project bundling are presented below:

- Identification of similar, repeating investments that permit structuring financial solutions to fund pipelines of similar projects (e.g. resilient retrofitting of single houses, water retention and purification equipment installation, and last mile junctions to fresh water, waste treatment and telecommunication systems);
- Identification of considerable infrastructure assets and systems investments that generate revenue to be further structured and promoted for PPPs (e.g. city-level wastewater reuse systems);
- Identification of interrelated infrastructure and other sector systems that need a territorial approach and consist of various interventions (e.g. seaport with land-transport infrastructure surrounded by populated coastal areas prone to inundation). It is possible to extract projects of different natures from this integrated intervention to be put forward as stand-alone investments. However, separating interventions may substantially undermine overall resilience against climate and natural hazards. For such territorially integrated approaches, it is advisable to create a financial and legal entity called a special purpose vehicle (SPV) that prepares interventions for the whole area in an integrated manner and sequences their implementation. Such project grouping can be financed by issuing bonds that may attract private institutional investors with potential public sector de-risking financial tools.

9. Further analyses leading to complete programme or projects proposals

9. Further analyses leading to full programmes or projects

The granularity achieved by the methodological approach up to this stage is favourable to crowd in much more funding from technical assistance. An integrated approach to projects enables understanding what additional analyses, capacity building, engineering approaches, or climate data are necessary to create meaningful interventions. It enables justification of requests for technical assistance and assignment of precise results such technical assistance will produce.

Moreover, at this stage of the project concepts pipeline advancement, programmatic approaches can be defined and attract multilateral organizations to help finalise the programmatic approach preparation and assist in mobilizing finance.

Finally, at this stage, local governments leading the project pipeline generation and financing process gain sufficient capacity to supervise further development of programmes and projects, ensuring local ownership.

VII. Conclusions and recommendations

As presented throughout this position paper, the primary aspiration of this document is to work on improved structuring of climate adaptation projects that can translate into favourable financial valuations.

On these grounds, this paper provides a preliminary methodological approach for the creation of project concept pipelines that can improve project quality and substantially upgrade project climate response, leading to more efficient use of funds for better resilience. This document also provides preliminary analyses for the financial valuation entry points linked to project risk mitigation that the project pipeline can achieve.

Finally, this document presents a way forward for climate-resilient projects' cost and benefits valuation. This exercise help capture the interventions’ real social, economic, and environmental value and calculate impact. Combined with information on market failures, these joint analyses can lead to a better financial valuation of the cost of capital proposed by public partners. This will further enhance financial concessionality to attract private sector partners.

To summarise, this position paper proposes three main recommendations:

1. To shift climate-adapted project preparation from ‘climate-proofing’ of developmental interventions to climate-science-based project pipelines that can tackle climate and developmental problems in an integrated and cost-efficient manner while bringing higher impact;
2. To discuss further and create solutions to capture better climate resilience brought by such project pipelines into financial valuation and a better defined, commensurate cost of capital; and
3. To further amend economic analyses with climate-resilience value and to carefully analyse existing market failures. The combination of the two will further enable cost of capital adjustments, more efficient crowding in of private sector funds and creation of commensurate public de-risking options.

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