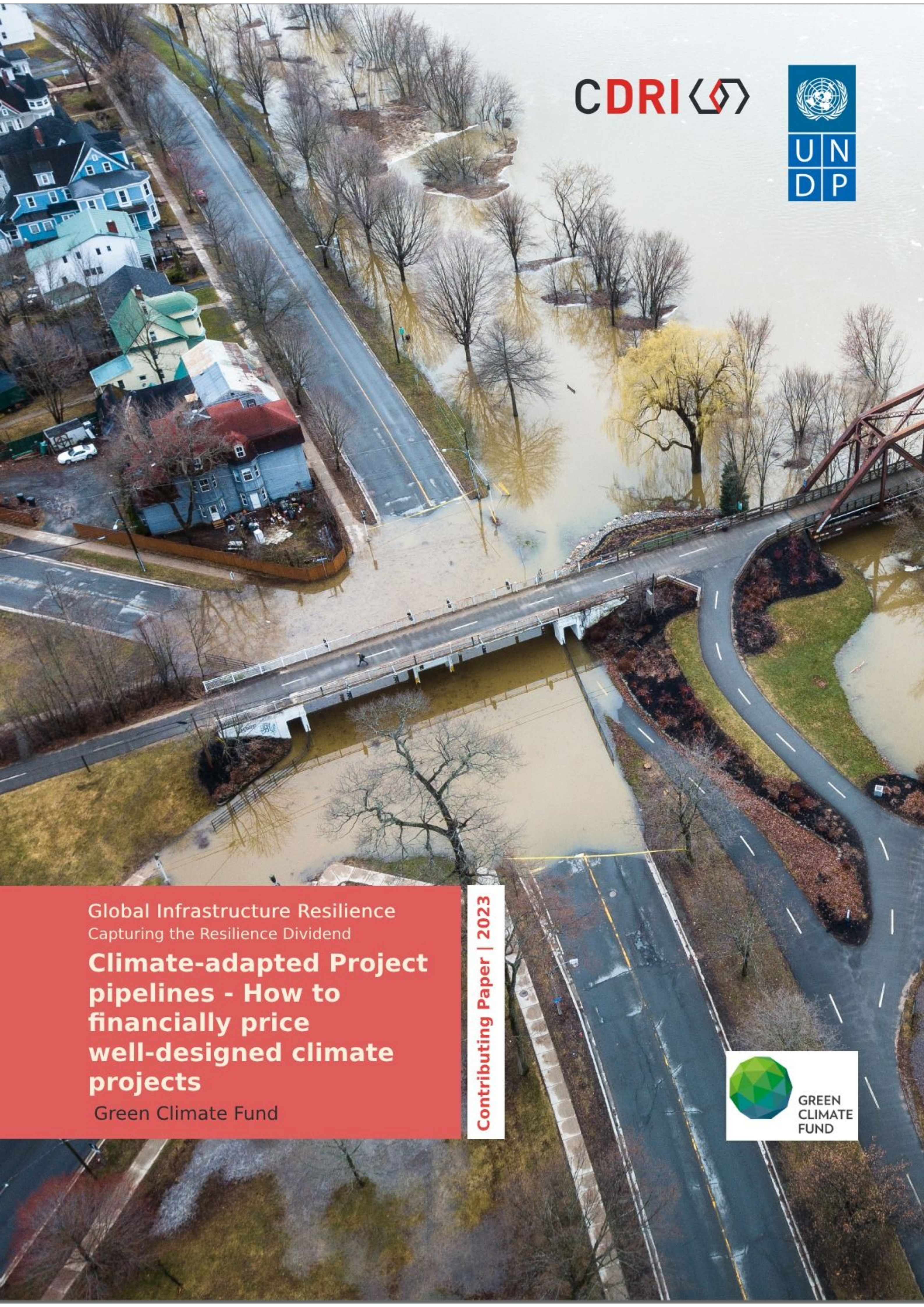

Global Infrastructure Resilience

Capturing the Resilience Dividend

Climate-adapted Project pipelines - How to financially price well-designed climate projects

Green Climate Fund

Contributing Paper | 2023

Climate-adapted Projects Pipelines

How to financially price well-designed climate projects

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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 further defines several problems and possible solutions to streamline finance for climate-resilient infrastructure.

Among the issues presented by the Chapter on Finance, this paper intends to contribute to select areas presented below:

- Challenge to mobilise finance for climate-based projects at scale and crowd in private flows wherever possible. The private sector can be a private project partner co-developing and managing the project and a private investor on the financial engineering level to bring equity. This paper aims to foster quantification of economic value[1] to incentivise the private sector by commensurate concessionally[2] that the public sector can provide in the form of co-financing or de-risking.
- Insufficient infrastructure governance can be fostered by developing integrated project pipelines for multi-year budgeting and systematic dialogue with potential financing partners. In the case of climate-resilient infrastructure, it also means public sector governance enabling access to climate data necessary for project structuring.
- Insufficient consideration of physical climate risks in financial valuations resulting in inadequate recognition of how a well-designed climate science-based project can strengthen project performance and revenues. The process-based methodology presented in this paper underlines how project risks can be tackled by project structuring quality, resulting in a much lower risk level. Consequently, reduced financial resources should be sufficient for financial de-risking.
- Market development focuses still on incremental costs of investment that correspond to stand-alone asset cash outflows and inflows instead of rewarding a comprehensive assessment of an interrelated system[3] and its overall ability to withstand specific climate risks where resilience is embedded in the design, operations, and economic viability.
- Economic analysis of projects neglecting benefits of climate resilience. Mainly, eco-systems-based adaptation[4] provides additional benefits and emissions sequestration. Nature-based solutions used as green infrastructure also prevent other emissions resulting from hard infrastructure production, transport, installation, and maintenance.

II THE POSITION PAPER GOALS

1. The Position Paper's main goal

The goal of this paper is to start a discussion and strengthen the dialogue where it already exists about changing a paradigm shift of project structuring. The rising threat of climate change on the overall function of human settlements and the availability of natural resources raises the question about the sustainability

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1 Economic value means…..
2 Concessionality….
3 Interrelated system…
4 Eco-systems-based adaptation, nature-based solutions

of the developmental approach that was followed for decades. Is it, and in which circumstances, still enough to add climate-proofing to developmental project structuring? At what entry conditions should a climate science-based approach prevail?

In any case, developmental needs should stay paramount but may not be the preferred starting point.

Secondly, infrastructure and related sectors are based on interaction among assets and surrounding nature. If this characteristic is not captured, climate or natural hazards disasters[5] can cause a domino effect of failures and much broader losses and damages. Such a situation leads to a rising risk ratio perceived negatively by potential financing partners.

The IPCC AR6 WGII report proposes "*transformational adaptation*", which can be defined as changing the fundamental attributes of a social-ecological system to address the root causes of vulnerability (as opposed to "*incremental*" adaptation projects which modify existing systems).

To go one step further, this document discusses the potential advantages of climate-science-based integrated project pipelines that may provide climate-adaptation synergies and systemically diminish project risks. Project finance practice should allow project risks to be brought down and enable crowding in more finance. Well-designed and managed project pipeline is also a powerful governance tool in the hands of public sector leaders.

Why are these (project) pipelines important?

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.

- For **governments**, pipeline development is an essential step in planning infrastructure, which 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 programs 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 programs.
- **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: Global Infrastructure Hub

2. The Position Paper detailed goals

The ambitions presented in Section 1 are translated below into detailed goals for the document.

2.1 Presentation of methodological steps that can lead to the development of climate-adapted project pipelines. The proposed sequenced approach assumes:

- Creation of projects pipeline based on climate science, information about possible natural hazards and embracing developmental aspects, e.g. raising the capacity of drainage to absorb a higher level of flooding, with a developmental activity of waste management to avoid blocking of drainage passages,
- Conceptualization of several interlinked grey[6] and green infrastructure projects developed together or in a well-planned sequence to avoid the domino effect of sequenced failures and ensure robust protection of people and assets (built and natural).

2.2 Building the case for further analyses and amendments to risk advice and pricing of climate-adapted projects by financial partners. To this end, the methodological steps in this paper are accompanied by

[5] Natural Hazards are explained further in Section 2, point 2
[6] Grey Infrastructures

project risks verification. Preliminary guidance on how each methodological step allows for diminishing project risks is presented.
Consequently, fewer funds should be engaged in financial de-risking when risks become lower due to better project performance. With climate-resilient infrastructure financial needs, it is worth exploring options to finance more solutions with fewer funds.

2.3 Raising awareness leading to economic costs and benefits analyses amendments. The methodology presented below intends to capture the advantages of the projects' pipeline approach and long-term climate-proofing of infrastructure systems that should be translated into higher economic benefits.

2.4 Strengthen the effectiveness of public and private investors setting special financing vehicles (also called financial instruments or programmatic approaches) by prioritising analyses of potential project characteristics before setting financial structures. A common practice of setting the financial vehicles first and mobilising projects as a second step results in slimming down the projects to fit finance, often jeopardising projects' quality and ability to sustain climate and natural hazards.

III CLIMATE HAZARDS AND PROJECT RISKS

1. Project risks in financial valuation

There are many approaches to listing project-related risks, commonly valued when the cost of capital is defined. A common denominator for the risks to be considered is its adverse material impact on the ability of the project promotor to service the re-payment of mobilised funds. The presented relation is the main link between project risks and the cost of capital. The higher the risks, the more significant the negative material impact on the re-payment ability and the higher cost of capital. In most cases, the ability to re-pay is reflected in the 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 finance that needs to be returned.

In other words, the higher the project structure's ability to mitigate risks that have an adverse material impact on re-payment, the lower the cost of capital should be. Consequently, finance providers should reward good quality projects which address the risks meaningfully with better financing terms.

The presented logic is an ideal scenario. In practice, there is no coherent project risk assessment guidance agreed upon among financial partners that will systematically allow the pricing of projects' quality. It is also not sufficiently valued, especially in the climate change context, that projects' pipelines enable further reduction of risks in comparison to the single assets approach. This paper discusses a common practice to price good quality projects (projects pipelines if there are interrelated systems) with higher concessionality.

To avoid doubt, the risks presented here are related directly to projects (specifically project concepts pipeline[7]). Vulnerability assessment brings an additional factor called value at risk. Value at risk is defined as the number of people and assets that can be adversely impacted by climate or natural hazards. Value at risk should be analysed under economic analyses. Paragraph V explains further the difference and interrelation of the project's risks and value at risk.

To present the potential of the climate-science-based project concepts pipeline to diminish risk calculation under the DSCR, the following list of project risks is selected:

- Construction risk: most commonly encompassing cost overruns and difficulty in achieving project expected performance at the scheduled time.
- Technology risk: often presented as part of the construction risk. However, in today's reality, characterised by unprecedented climate threats and fast-paced technological advancements, there is a need to look at technology risk separately.
- Cost/revenue/market risks: the cost risk is related to any cost overrun resulting from another aspect than construction risk. Revenue risk is observed whenever revenues fall below an expected minimum level. Market risks in this document focus on market failures. Market failures are inefficiency and existing market gaps threatening project successful implementation and maintenance. These 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 case of SIDS, exacerbated by distances in case of Pacific States)
  - stringent land ownership regulations, disabling effective infrastructure investments, e.g. enough public space to design climate-resilient roads with sufficient drainage and water discharge

[7] Project concepts pipleine

- insufficient demand resulting from limited awareness, e.g. cost of energy/water not incentivising efficient use
- limited access to insurance

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

- Natural resources/ supply risk: this risk category is often covered by the market risks section. In the context of climate change stretching the supply of natural resources like water, sand or healthy ecosystems, this risk becomes paramount and should be covered separately.
- Operating and maintenance risk (O&M): related to the quality of management of the assets. Specific market failures relating only to O&M may be assessed here.
- Political/ regulatory risks: concerning project quality, it mainly recounts changes in countries or regions' developmental policies and priorities, often resulting from 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: understood here as risks related to severe deterioration of the country's macroeconomic profile resulting from climate hazards impact. It is most prominent in SIDS countries, where each hurricane or cyclone may directly impact the country's debt profile and destroy overall value chains, e.g. energy supply to the country.
- Documentation risk/ engineering risk: related to the overall robustness and consistency of the project documentation, is a prerequisite for effective implementation, construction and management.

2. Climate hazards and their translation to project risks

The potential occurrence of a climate or natural hazard may cause loss of life, injury, or other health impacts, damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.
Climate hazards are divided into acute hazards, such as extreme weather events like storms or heatwaves, and related climate disasters, like floods, landslides, droughts, and wildfires. The second climate hazard group, called chronic hazards, is characterised by the prolonged onset, which includes rising sea levels, increasing temperature, or changing rain patterns. Natural hazards, often occurring in combination 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 to project risks is vulnerability analyses from existing analysis and literature, including the IPCC report. Stepping from exposure of people and assets to hazards through their sensitivity (possibility to be adversely impacted) and adaptive capacity (existing capacity to mitigate adverse impacts) leads to the assignment of vulnerability. This exercise enables the translation of climate and natural hazards to project structuring elements and subsequent mitigation of project risks.

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

III LIMITATIONS OF THE RESEARCH BEHIND THIS POSITION PAPER:

1. In the project finance practice debt service cover ratio is related to substantial project risks, but the actual financial cost of each technical risk is based on the expert's judgement. In other words, the calculation of the cost of capital is not quantified in the ranges or similarly straightforwardly. Thus, this paper aims to start discussing standard quantification among potential financing partners and systemic financial rewarding of project quality.
2. Most innovations in valuing climate-adapted projects' performance are looking at:

- single assets, not projects pipelines based on the systemic approach to interlinked infrastructure (linear or territorial),
- developmental projects incorporating physical climate risks if these are a substantial threat to the asset performance (e.g. raising heat impact on power plan colling capacity)

Therefore, this paper is not yet able to prove in a quantified manner (using economic or financial indicators) the superiority of performance and benefits of projects:

- coming from integrated pipelines, and
- created out of a climate rationale, with developmental aspects added later in the project development.

However, it is anticipated that this paper should enable better financial conditions for integrated and well-sequenced project pipelines when these result in substantial risk mitigation and much more resilient development.

3. There is still minimal information on the physical resilience of ecosystems in comparison to hard infrastructure, represented by coded engineering options. Therefore, nature-based solutions 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) list benefits and costs from the developmental perspective. More advanced approaches, like ADB Analysis of Climate-proofing Investment Projects', discuss the benefits of climate-proofing activities and introduces other ancillary benefits of climate-adaptive solutions. However, there is no systematically developed list of climate-based projects' costs and benefits. Creation of mutually agreed climate-related expenses and benefits and monetisation approaches would help identify suitable time frames for cash flow analyses and quantifying corresponding net present value.

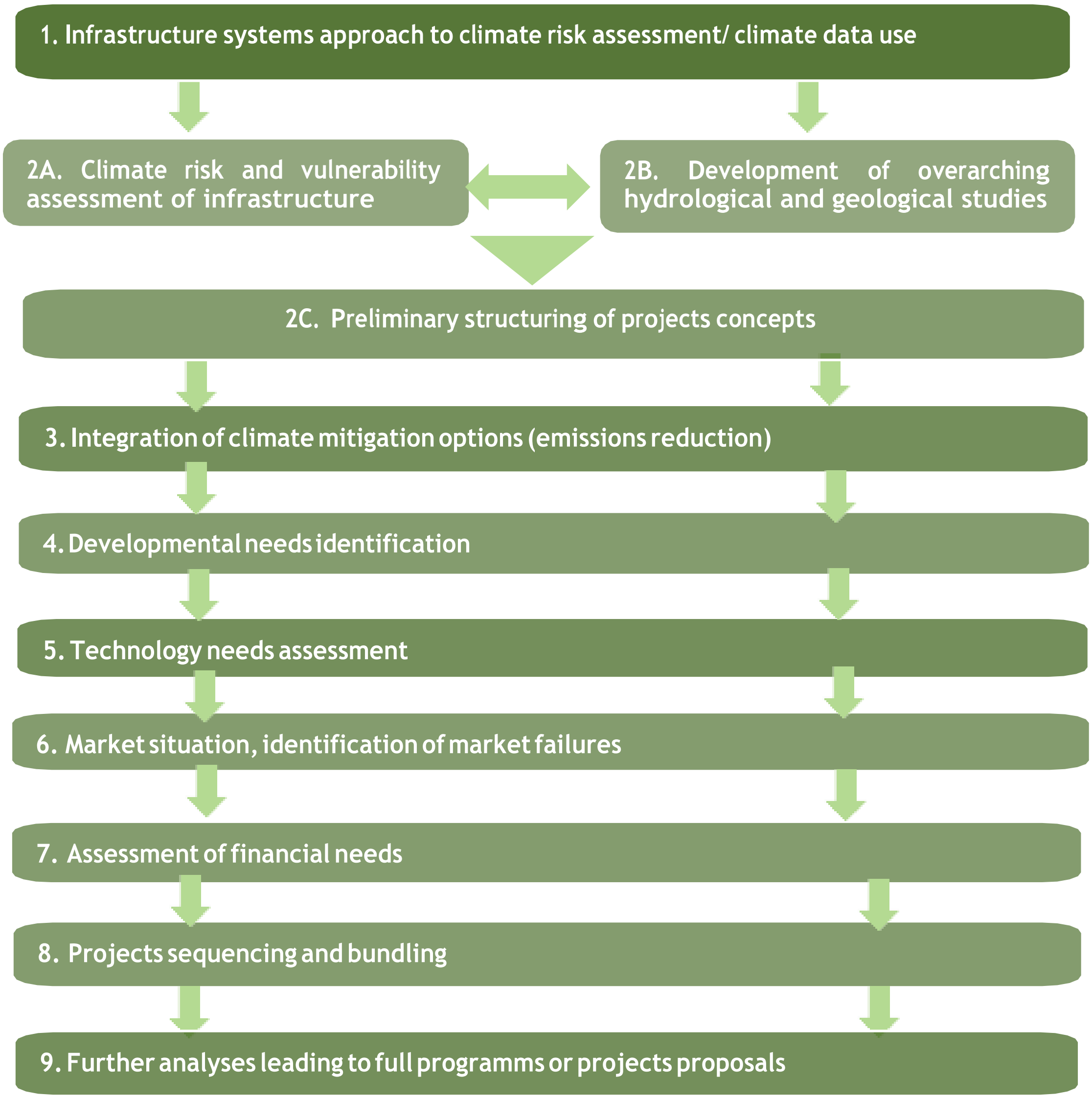
V CLIMATE-ADAPTED PROJECTS PIPELINES

The methodology for the integrated projects pipeline proposed in this document builds on analyses of De Connick et al. (2018), Noble et al. (2014) and Ley et al. (2022), resulting in a proposal of assessment of adaptation options across six dimensions of economic, technological, institutional, social, environmental, and geophysical feasibility (Singh et al., 2020). Analysis of the feasibility of each of these adaptation options and their potential for risk mitigation co-benefit is summarised by Ley et al. (2022). In other words, the six dimensions present analytical scope for selecting climate-adapted projects. In other words, the quality of the project is rooted in these areas. Thus, these are good starting points for risks assignment.

The methodology below aims to describe the potential of the quality integrated projects pipeline in mitigating risks. Suppose financial valuation systematically prices projects for their quality. In that case, the financial de-risking may be used only for remaining residual risks resulting from uncertain aspects at the project development stage.

This process should allow using scarce financial resources more efficiently by financial de-risking of more initiatives with fewer funds and shifting resources to the complete project's development stage (e.g. for robust feasibility studies).

The diagram presenting integrated and well-sequences projects concepts pipeline is shown below:



At step 6, the project concepts' pipeline quality boosting, risks mitigation and economic value assessment end. This is just an initial assumption, and future analyses may indicate additional steps or steps adjustments.

Steps 7, 8 and 9 (below) present the second stage, where information gathered under Steps 1-6 translates into assessing financial resources, project concept sequencing and bundling to attract finance. A further listing of the necessary documentation for full project proposals and other activities to address market failures allows for attracting additional finance from technical assistance.

1. Infrastructure systems approach to climate risk assessment/ climate data use

1. Infrastructure systems approach to climate risk assessment/ climate data use

1.1 Description of the step

This step is supposed to set a scope for analyses leading to the project concepts pipeline conceptualisation. A functional area of interrelated infrastructure and surrounding ecosystems needs to be defined to achieve this goal.

The best starting point to outline what system we are looking for is to review existing literature and reports presenting events resulting in infrastructure and eco-systems damage, services disruption, life losses and injuries. Secondly, interrelations among infrastructure assets, economic activities and social services must be set. Sequenced failures observed within past events and resulting from characteristics of assets cross-dependence must be captured. These analyses should enable the definition of an interconnected area for intervention (also called a functional area).

The next step would be to cross-check the findings with existing developmental plans and ongoing and planned investments within the functional area.

The interrelated system approach can have many forms. The below list presents just a few options:

- Systems of infrastructure, *e.g. energy, transport, water, etc.*
- Intersection of infrastructure systems (often analysed along with single infrastructure systems), *e.g. energy for water pumping or sewage treatment.*
- Interrelated sectors with infrastructure, *e.g. water at the intersection with tourism; the intersection of infrastructure systems, buildings and economic activity sectors in urban areas.*
- System 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 systemic level, broader research on climate data availability should be launched.

The most challenging exercise is climate data gathering and layering with natural disaster data and infrashistorical systems while capturing historic trends and the most probable future climate scenarios. However, more and more examples of models and approaches can be replicated. This practice shows that even if climate data consists of many gaps or is not available on high resolutions, information with additional experts' judgement and modelling is sufficient at this stage to conduct a system-based vulnerability assessment.

As this step is a preparatory stage for vulnerability analysis, more information and case studies on climate data analytics are provided in the next section.

1.2 Project risks mitigation

As this step is a preparatory phase for the vulnerability analysis, mitigation of project risks will be presented within the vulnerability assessment section. However, it should be underlined that this initial step's quality and consistency will directly mitigate several risks, including cost/revenue/market risk, natural resources/ supply risk, political/ regulatory risk and documentation risk.

On the other hand, this step might be a turning point if a severe climate hazard threat is defined. The most explicit example of such a situation can be a case of river basins and related water stress. Suppose historical data and the most convincing predictions present a substantial risk of exhaustion of freshwater resources. In that case, this analysis step should result in a revision of development patterns before project concepts are defined.

In this situation, the vulnerability analysis should start with a thorough examination of water resources available for several decades in the future. With specific geological and hydrological studies, the water supply/ natural resources risk level can be estimated. If this risk is extremely high and may result in exacerbated water supply exhaustion, the paradigm-shifting change of the overall system should be discussed.

Similar cases are visible in coastal areas, often characterised by the density of human settlements and economic activities threatened by sea level rise in conjunction with tsunamis.

From the risk analysis perspective, the presented situation means that the supply/natural resources risks can bring all other project risks (construction risk, technology risk, revenue risk, operations and maintenance risks) to an unacceptable level by any financial partner. It indicates that any investment based on the existing system can fail without a paradigm shift in development patterns.

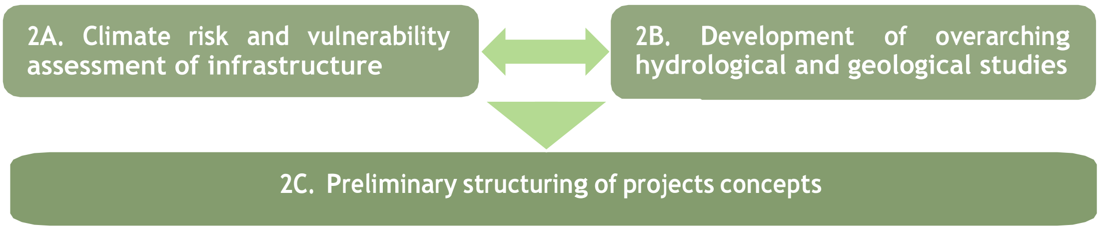
Consequently, with the long-term engagement of public finance, often in the form of debt, the non-performance of several sectors and systems dependent on the water resources can result in the augmentation of macroeconomic risk and deterioration of the overall macroeconomic performance on the level of city, region or the whole country (observed often in the SIDS countries).

National Adaptation Plans (NAPs) are one the best strategic documents to conduct a presented assessment and analyse further how the new development paradigm should look like. Equally, NAPs can use the overall methodology presented in Section V to conceptualise the project concepts pipeline.

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 assets density, and previously observed losses and damages are a starting point to define the benefits of the decisions undertaken based on these variables.

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



2.1 Description of the step

Vulnerability assessment is a process that allows defining the most vulnerable areas to climate and natural disasters. In the case of vulnerability analyses of infrastructure systems, the most common approach is the layering of maps that enable the visualisation of the concentration of hazard stressors and infrastructure networks and assets. In addition, the attribution of costs of services disruption, human settlements concentration, economic activity concentration and other social aspects which capture the most vulnerable groups should be defined. 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-systems maps as an additional layer. It supports the visualisation of the interaction of nature with endangered infrastructure systems. Consequently, it becomes possible to use nature-based solutions to protect built-in structures and enhance natural resources supply.

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 agri, 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*

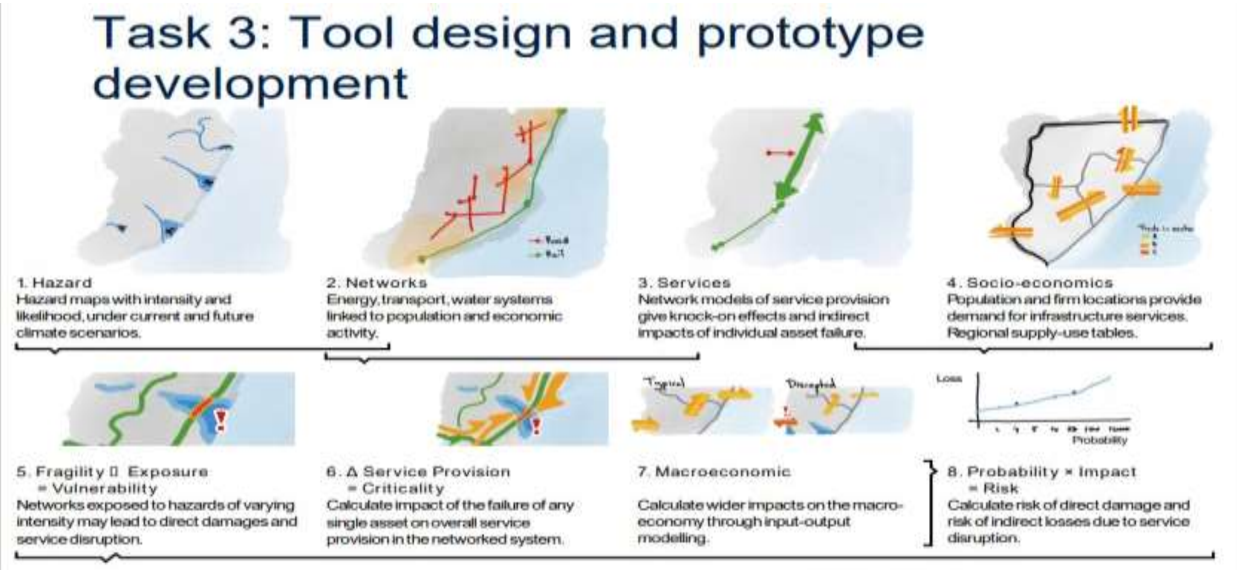
Areas with the highest cumulation of factors resulting from information layering are deemed the most vulnerable. In other words, these places are the hot spots that need climate-proofing solutions and natural disaster protection.

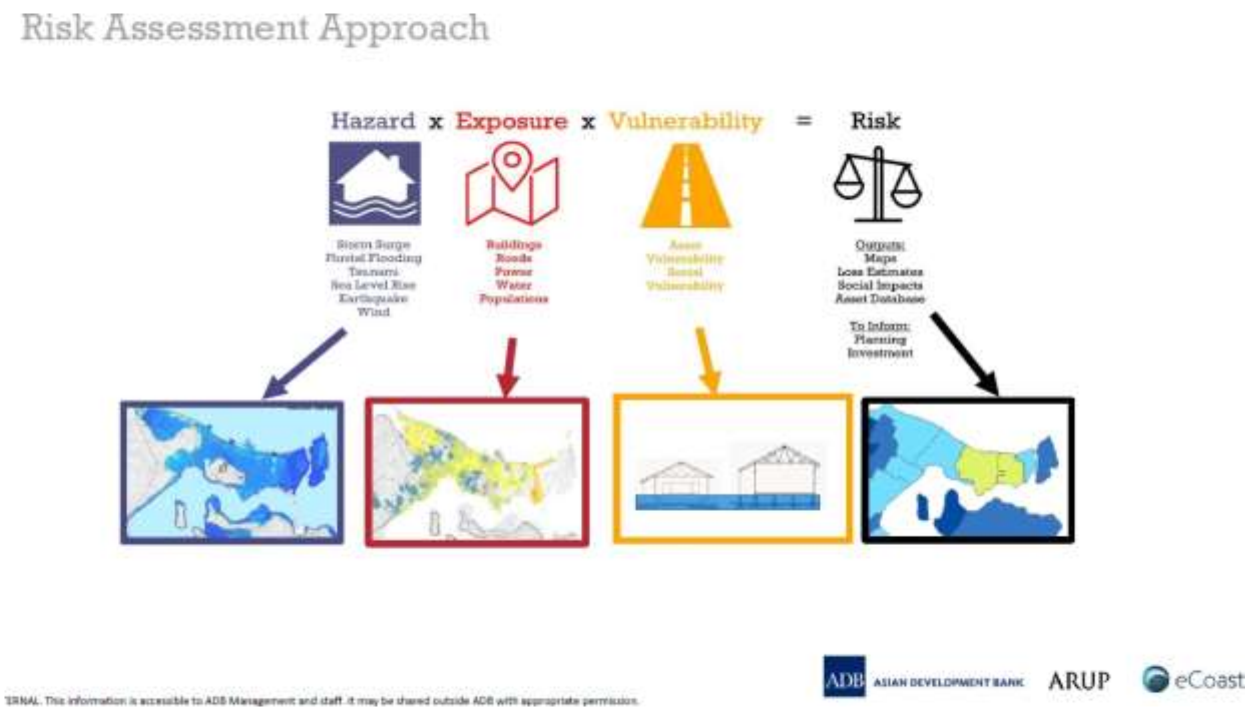
Examples of multi-hazard risk assessment solutions

The most efficient way to capture the vulnerability of people and assets is to structure methodologies or tools that, once designed, can serve for continuous planning, project conceptualisation, and other data gathering.

The below-presented case studies capture possible solutions tested in different parts of the globe and ready for replication:

Two case studies: Jamaica Systemic Risk Assessment Tool (Oxford University) and Tongatapu Multi-hazard Risk Assessment (ADB) with analytical approach explanation





As presented above, multi-hazard analyses demonstrate characteristics of the climate or natural hazards' impact on the defined area. These are essential to 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. Such analyses are resource intensive. Thus, there is a tendency to conduct geological and hydrological studies much later, at the single project level. Consequently, project promotors try to narrow down the scope and tend to prove project viability. It leads to subjective assessments and a substantial increase in all project risks.

Therefore, conducting geological and hydrological studies with vulnerability analyses is advisable when additional information layering can still serve to identify more efficient interventions. Strategic documentation like NAPs (with the substantial funding for these documents) is best placed on developing such analytical approaches and informing how future investments should look while substantially diminishing project risks.

Basic project information
AE: UNDP
Total project financing: 41.2M
GCF financing: 25.6M
Co-financing: 15.0M
Beneficiaries: 3.7 million people (200,000 households)

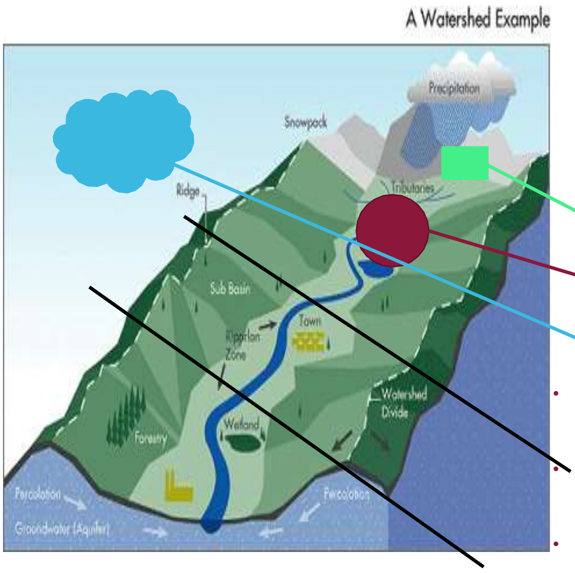
Additional information
Overall goal: to promote a paradigm shift in dryland pastoral and farming systems through an integrated approach by increasing resilience of food production systems and improving access to climate-resilient water sources
Includes water balance analysis for current and projected water usage from deep and shallow wells to ensure that abstraction rate is < recharge rate per year

CASE STUDY: HOW Vulnerability Analyses and geological and hydrological studies can lead to a substantially reshaped projects pipeline, diminishing project risks.

A typical list of interventions proposed for finance related to the same river basin:
- Climate resilient agriculture project (irrigation schemes)
- Fresh water for urban area, including pumping from freshwater resources
- Raising the capacity of hydropower plant to meet net-zero emissions targets
- eco-systems restoration project

Projects are proposed by different sectors' administration with a very limited co-ordination. Consequently, project promotors develop separate climate-proofing, hydrological, geological studies and ultimately engineering specification

Problems inherited from the development of projects in separation often result in:
- implementation problems, raising construction risk
- Underperformance due to scarcity of natural resources (water), raising the risks of costs/ revenue, OPM, documentation/ engineering
- local communities' unrest due to maladaptation effects, raising OPM risks
- Deterioration in the macroeconomic situation of the region or event the whole country, raising macroeconomic risk



- All projects relate to the same water resource that is shared by 3 countries.
- All proposed projects relate only to one country.
- All proposed projects assume water extraction from the same watershed with limited water resources.
- This watershed is additionally stressed by climate change with prolonged droughts and heavy rains causing flooding

A hydropower plant sits in the upper part of the river system

A big metropolitan area sits by the river. The river is a main source of fresh water for the city.

Eco-system preservation project is proposed outside of the area of the watershed

- **To summarize, projects claim water extraction from the same water resources that are already stressed by climate change. Thus, water resources will be shrinking.**
- **Private sector makes such analyses when they decide on the profitability of the project. Thus, private sector might drop the project or sign safeguarding contracts to assure high penalties for the government if their profits are at risk.**
- **Eco-system preservation project is outside of the watershed. So, it will not perform catalytic role of water preservation.**

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:
- Sever risk of maladaptation resulting from an increase in water extraction while climate change analyses predict even more scarcity of fresh water in the future
- Deteriorating hydrological situation e.g. insufficient water re-charging resulting from developmental activities
- Unfavorable geological structure limiting water preservation and facilitating water run-off

Joint systemic climate risk assessment, vulnerability analyses, hydro- and geo-analyses leads to a redefinition of projects pipeline to:
1. Wastewater treatment and water-reuse programme for the metropolitan area)
2. Aquifers recharging, wetlands preservation, eco-systems restoration integrated programme (multi-projects programmatic approach for 3 countries)
3. Agriculture project focused on water re-use and harvesting; new boreholes carefully assessed based on the overall watershed capacity assuming other projects load
4. Resilience-based energy mix analyses to be conducted before deciding on the non-harm energy solutions to be translated into projects concepts
5. Small-scale RE projects to start energy transition
6. Locally led eco-systems management project to preserve existing eco-systems in the watershed

2.2 Project risks mitigation

The presented approach to vulnerability analyses leads to a transformational decrease in projects' risks. More details are described in the table below:

Risk	Risk mitigation factors are to be valued in project quality assessment and, consequently, cost of capital.
Construction risk	Limited in a transformational way by: • changing subjects for future engineering design (reshaped projects concepts pipeline) • selection of projects that mitigate paramount risks, e.g. natural resource risk • integrated information about climate and natural hazards vulnerability • provision of geological and hydrological studies informing the future design of interrelated projects
Technology risk	Limited in a transformational manner as for the construction risk.

	In addition, the Tongatapu Multi-hazards Risk Analyses provides information on the limitation of existing technologies and technical solutions to refurbish existing infrastructure successfully. Consequently, replacement of investment may be suggested.
Cost/revenue/market risks	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 is not limited; the careful assessment of this risk from the climate change perspective results in selecting this risk as a significant threat and transforming the whole project's pipeline.
Operating and maintenance risk	The proposed approach substantially limits O&M risk by limiting a cascading effect of construction, technology, cost and revenue risks to impact operations and maintenance activities adversely.
Political/ regulatory risks	Public authorities can only undertake the overall process proposed in this section. Public sector ownership and leadership of this process substantially diminish perceived political risks. Public authority's leading role also enables analyses of regulatory aspects to determine regulatory changes essential for implementing proposed projects effectively. Thus, this can be the most effective starting point to reduce additional regulatory risks.
Macroeconomic risk	In case the analysed area represents the substantial cumulation of GDP and financing of the projects pipeline relies heavily on public debt, avoided losses in infrastructure performance 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 phase of vulnerability assessment, supported by other specific earth structures and characteristics-related studies, is the best starting point to define costs and benefits that should be analysed on the level of the project concepts pipeline. In addition to typical costs and benefits described for development projects, specific climate and natural hazards costs and benefits should be captured to present a complete list of advantages of selected interventions and capture them in the Economic Net Present Value and Economic Internal Rate of Return (EIRR).

The scope of this position paper is just a voice articulating a need to work on this approach. A broader discussion among the project structuring experts is necessary to provide a tangible list of costs and benefits that can be systematically incorporated into economic analyses as a global practice.

A non-exhaustive list of potential additional benefits and externalities that can be captured and monetised under economic analyses 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
- Value of avoided O&M costs

3. Integration of climate mitigation options (emissions reduction)

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 becomes crucial to use any opportunity to reduce emissions using energy-efficient solutions and introduce additional emissions sequestration options.

Thus, when a preliminary list of integrated project concepts pipeline emerges from the previous analytical step, it is the most opportune moment to cross-check how to reduce emissions further.

It needs experts' judgement to set an appropriate list of measures for selected interventions. Some examples are listed below:

- Selection of energy-efficient features for refurbishment or in the design of newly built structures
- installation of renewable energy engines
- exploration of green solutions as alternatives for hard infrastructure (avoiding highly emitting production of infrastructure components, preventing emissions resulting from transport and installation of infrastructure, additional sequestration of emissions by natural habitats)
- use of low-emitting transport solutions during implementation and O&M phases of the project

However, it must be emphasised that careful engineering design is necessary to ensure that climate-resilient and emissions-reducing solutions are not contradicting each other, e.g. energy efficiency solutions do not diminish the structure's resilience against wind impact, e.g. climate- proofing of roofs incorporating load resulting from solar panels.

3.2 Project risks mitigation

The mitigation factor for project risks resulting from this step is not as pronounced as in the case of the previous section.

The main gain can be presented for cost/revenue and regulatory risks. With a global shift to price low-emission solutions and rising costs of highly emitting energy generation and technologies, it may just become too costly not to invest in low-emission options.

Additionally, some financial resources may not be available if emissions-intensive fossil fuels are promoted throughout the project value chain.

3.3 Potential links to economic analyses

The significant benefits are emissions reduction and avoided fragility resulting from dependency on fossil fuels.

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. It can be pronounced by the need to start conceptualising interrelated projects with climate change impact assessment. However, it does not change the fact that developmental aspects like food security, fresh water supply, waste management, water sanitation, energy access, and accessible transport are still paramount. In other words, the achievement of developmental goals stays at the core but is feasible and needs a change in the investment generation process.

In addition to the above, it is encouraged that crucial interdependencies of climate-proofing and developmental activities are defined at this stage.

Examples of such verification elements 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 the drainage passages
- capacity of coastal eco-systems to diminish the impact of tidal waves needs assurance that toxic substances do not jeopardise the quality of these eco-systems
- resilience of infrastructure assets needs to be secured by land development plans, e.g. public ownership of land at the road sites for future drainage capacity improvements and preservation of wetlands to balance water flows and saltwater intrusion.

4.2 Project risks mitigation

The fact that additional developmental aspects are considered brings further mitigation of several risks, including construction risks, cost/revenue risks, and O&M risks.

4.3 Potential links to economic analyses

As practised by many organisations, all developmental goals should be presented in the cost and benefit analyses.

In case the additional developmental activity is included to mitigate adverse impacts of climate change or natural hazards, e.g. waste management for drainage performance, it should be captured on the level of developmental benefits.

5 Technology needs assessment

5. Technology needs assessment

5.1 Description of the step

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

- Intellectual property (IP) rights and licencing: this is not only the cost of the licence for a commensurate period but the equally important cost and time for legal arrangements and negotiations that need to be run by specialised lawyers and engineers. Highly specialised experts are essential to advise the best licencing rights that give sufficient access 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 system of infrastructure, costs and time to introduce adjustments.

- Continuous availability of technology servicing may be ensured by acquiring the technology or more significant spare parts stocking.
- Proper, effective use of the technology and ability to ensure further technology scalability to new projects in case the technology proves its efficiency.

Technology needs assessment is a preparatory process that enables preliminary evaluation of existing technologies on the market that can be responsive to the engineering needs of the projects' concepts pipeline. This assessment undertaken at this early stage when the integrated projects' pipeline is still at the concepts 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.
- Reshape preliminary projects' concepts in case technology transfer is too costly or the regulatory environment is not yet conducive and needs substantial time to be transformed.
- Analyse the effectiveness of enhancement of locally available solutions, e.g. ventilation windows used in houses that substantially diminish wind shear effect, protecting the structure from collapsing and roofs from being torn off.
- Analyse interrelation and junctions in the infrastructure systems that introducing new technology will impact.
- Define situations where there is no existing technology to ensure infrastructure integrity, e.g. when the strength of the combined flooding effect of fluvial, rain and wave tide cannot be addressed by any existing engineering solution.

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

5.2 Climate and project risks resolutions

Risk	Risk mitigation factors are to be valued in project quality assessment and, consequently, cost of capital.
Construction risk	It is limited by carefully selecting technology that will work with the rest of the existing system, proper contracting and licencing, and thorough assessment of necessary technical capacity for design and civil works.
Technology risk	Each of the activities presented in section 5.1 substantially de-risks the use of selected technology. These analyses have an additional de-risking effect as they allow for careful costing of all arrangements related to technology transfer. Fragmented technology transfer planning and underestimation of technology transfer costs are the main risk factors repeatedly happening in climate projects' structuring.
Cost/revenue/market risks	A robust approach addresses cost and revenue risks to technology transfer analyses and careful costing. A commensurate contracting and licencing and mitigation of knowledge and technical capacity gaps significantly raise the confidence in technology capacity to perform as planned.
Natural resources/ supply risks	Supply risk mitigation results from selecting proper technology that can perform well under changing climate conditions and a high propensity to natural hazards.
Operating and maintenance risk	The O&M risks are substantially diminished by much lower construction, life cycle costing for technology transfer and use, and decreased natural resources and supply risk.

Political/ regulatory risks	Technology transfer analyses that embrace the regulatory environment and allow the selection of technologies that can work within the existing regulatory environment substantially diminish regulatory risks. Alternatively, the public sector's commitment to creating a regulatory environment conducive to technology transfer positively impacts both political and regulatory risk levels.
Macroeconomic risk	In case the functional area or integrated system represents the substantial cumulation of GDP and financing of the projects pipeline relies heavily on public debt, avoided losses in infrastructure performance and business continuity can have a considerable 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.

5.3 Potential links to economic analyses

Technology transfer can hold specific benefits that may not be observed with the old technology, e.g. net increase in jobs, positive environmental impact/ declining negative impact, and raising tourist value. Thus, these benefits should be introduced in the economic assessment.

6 Market situation, identification of market failures

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 and O&M constitutes a substantial risk for the project.

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

The project concepts pipeline is the best moment to address existing market failures as such activities may need substantial time to be tackled and relate to a broader environment. It is also more effective to introduce systemic solutions, e.g. market awareness campaigns or technical capacity training bundled together under special technical assistance packages.

Many market analytical approaches present lists of crucial market failures that need to be assessed depending on project characteristics. Manuals (Annexes) to the EU Ex-ante Assessment for Financial Instruments are an excellent example of such catalogues, among other things, lists of potential market failures related to emissions reduction or urban and territorial investments[8].

However, one market failure must continually be assessed and may occur when local partners lack sufficient capacity to implement and finance project concepts pipelines emerging from the proposed

[8]https://www.fi-compass.eu/publication/manuals/manual-ex-ante-assessment-guidance-vol-iv-supporting-shift-towards-low-carbon
https://www.fi-compass.eu/publication/manuals/manual-ex-ante-assessment-guidance-vol-v-financial-instruments-urban-and

methodology. The insufficient financial and technical capacity allows for the need for external project implementation partners and additional financial resources to be mobilised.

This exercise also enables the public sector, which manages the project concepts pipeline development process, to propose local partners as subsidiary implementation partners and O&M collaborators. Thoughtful planning for such engagement can stimulate the faster capacity building of the local market and enable locally driven design, implementation and O&M management in the future.

7. Assessment of financial needs

7. Assessment of financial needs

Information gathered throughout the process presented in steps 1 to 6 should give lots of inside to calculate the required funding for the project concepts pipeline further development.

As presented in Section III, point 1, substantial mitigation of projects pipeline risks should allow valuating better project financial conditions, expressed in preferable DSCR. In addition, analyses provided until this moment will also give a good understanding of the potential costs of the project's implementation and O&M.

The proposed methodology defines investment needs starting from systemic climate risk tools, possibly enhanced by natural disaster risk assessment. Thus, under the designated hot spots, projects' concepts pipeline might encompass private and public sector projects. From this perspective, the methodology automatically indicates the local private sector that should be engaged.

Second-level private sector engagement can be defined if projects are characterised by revenue streams, which can be a preliminary indication for public-private partnerships.

Finally, a well-bundled project pipeline can attract private sector institutional investors, e.g., mobilised by climate bond issuing.

Indication of public and private partners owning the assets and systems of infrastructure and surrounding ecosystems guides potential project promotors and the first layer of investors, e.g., utility company whose infrastructure systems is under tremendous climate stress.

In most cases, other national and international financial partners still need to address a substantial financial gap. In addition to private resources that PPP can mobilise and on the level of institutional investors, additional public resources will still be required. Mobilisations of additional public funds can be incentivised by:

1. High-quality projects concepts pipeline that can be achieved through this methodology enabling maximum de-risking of projects attributable to their quality (mitigation of project risks) that proves much lower needs of financial de-risking for the residual risks.
2. Identification and monetisation of all additional economic benefits and reduction in economic costs will result in well-proven 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. Most of these institutions use cost-benefit analyses to define projects' developmental (socio-economic) value beyond their financial revenues. The more profitable the project is for people and the environment, the better financial conditions can be proposed.

Consequently, provided analyses on project risk mitigation and economic benefits valuation constitute essential argumentation for international public finance mobilisation. Both elements should also bring added value for impact investors representing the private sector.

8. Projects sequencing and bundling

8. Projects sequencing and bundling

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

Projects sequencing and bundling are even more interconnected and are part of the same analytical step. However, for a better presentation of the characteristics of these elements, the two are presented separately in this section.

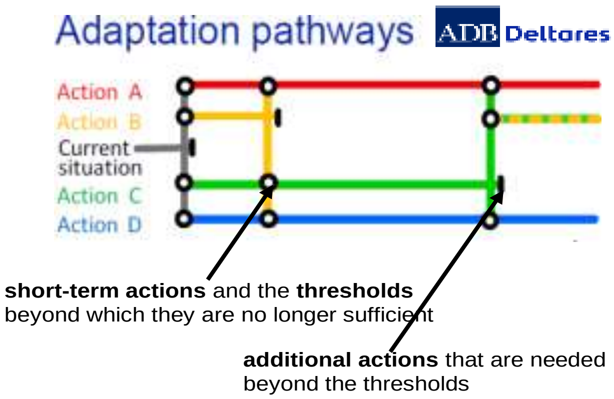
Projects sequencing is a multi-criteria exercise that defines placement in time of development of complete project documentation and subsequent implementation. Many aspects need to be accounted for to sequence well project timetable. Analyses conducted under steps 1 to 7 provide vital information necessary 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 destruction can cause
- criticality of the resource that is a driving force for the overall system, e.g., fresh water supply. In case there is a high risk of water supply shortages, water recharging activities should be prioritised
- 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 issue, e.g. introduction of new regulations, creation of specific new capacity of local engineers
- level of finance and implementation capacity that is more conducive for specific projects from the pipeline

The results of this multi-criteria sequencing analysis also have additional de-risking value as projects are implemented only when there is a conducive environment. On the other hand, the proposed criteria allow for avoiding losses and damages due to prioritising the most critical interventions.

There is also another effective tool that enables intervention sequencing based on the real options analysis. When investments are conducted under uncertain climate scenarios, the most efficient implementation approach is to design lighter infrastructure in short to medium-time horizons and enable further refurbishment in the future. Real option analyses are a design approach that allows step-by-step enhancements.

Asian Development Bank, in cooperation with Deltares, developed an approach called Adaptation Pathways. This multi-investment approach presents the pathways to resilience, where asset enhancements are envisaged from the outset. 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. Infrastructure developed under real option analyses substantially delays the moment of the infrastructure obsolescence.



Projects bundling is an informed decision of projects 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, to decide what kind of financial engineering and financial vehicle can be structured to finance emerging projects effectively. Projects' characteristics are essential pre-requisite to define the best funding structure and inform the use of different financial tools like debt, equity, mezzanine, grant, guarantee, technical assistance, and a combination of these tools to maximise the funding performance. The upfront setting of financial vehicles without thorough information on projects' attributes results in the underperformance of financial vehicles and the inability to find projects that fit prescribed financial mechanisms.

Projects bundling is also essential to understand possible layers of private finance engagement (3 levels of private finance engagement presented in point 7). In other words, it enables the blending of public and private funds.

Projects bundling and the following financial engineering needs careful assessment of experts representing different technical skills, engineers, economists, lawyers, and financial experts. Three examples of projects 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 and waste 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 types of interventions, e.g. seaport with land-transport infrastructure surrounded by populated coastal areas prone to inundation. It is possible to capture separate projects that can be extracted from this integrated intervention. However, separating interventions may substantially undermine overall resilience against climate and natural hazards. For such territorial integrated approaches, it is advisable to create a special purpose vehicle (SPV) that prepares interventions for the whole area in an integrated manner. Such projects' grouping can be financed by issuing bonds that may effectively attract private institutional investors with potential public sector de-risking financial tools.

9. Further analyses leading to complete programs or projects proposals

9. Further analyses leading to full programms or projects proposals

The granularity achieved by the methodological approach until this stage is also favourable to crowd in much more funding from technical assistance.

Some programmatic approaches and projects can be attractive enough to be included in the projects' pipeline of international organisations that will use their technical assistance to lead programs and projects to the financing stage.

In other cases, gathered information permits the structuring of detailed terms of reference to seek different capacity-building funds, NAPs or country programs financing grants.

Finally, local government leading the projects pipeline generation and financing process gain sufficient capacity to supervise further development of programs and projects, ensuring the country or any other local ownership.