The World Bank

# Performance Based Contracting: Climate Risk Adaption

Task 2

## State of the Industry Review

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This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number

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# Executive Summary

In developing countries and in rural areas, in particular, roadway infrastructure provides direct and indirect services that are critical to social welfare and individual livelihoods. Roads support economic activity, health services, agricultural practices, education, political participation, and other essential functions of a healthy society. In general, climate change threatens the ability of road networks to remain passable and connected, two functions that are highly critical in low-density areas where alternative routes or additional transport options are limited.

## Concerns

Active participants in the Performance-Based Contracting (PBC) industry are keenly aware of the implications of climate change and how they can affect risk exposure over the lifetime of a project. Since current design standards do not explicitly require contractors and designers to plan for climate change as part of projects, it is the responsibility of developers to plan for resilience through risk based design. Unfortunately, many developers feel that the added cost of resilience precautions can render current roadway contracts non-viable. The enlarged volume and quantity of physical assets, such as bridges, coupled with an increased frequency of maintenance needs, such as cleaning, reduces profitability of contracts to the point where tolling cannot cover expenses. Projects will ultimately not be profitable without changes to the contracting schemes.

## Industry Trends

This investigation has also considered how climate change effects are being considered in other sectors such as water (Decision Tree Framework) which has a detailed system to stress test projects to climate change impacts and rail (UK Network Rail) where the developer has planned investment programming around climate change. Evaluation of these and other case studies has indicated a common theme that shows downtime metrics, lifecycle changes and cost implications govern investment appetite.

## Takeaways

PBC projects face a number of pressing issues based on the status quo contracting terms and current arrangements. Understanding these critical points (listed below) allows for reallocation of risk to parties more suited to manage the impacts.

1. How do we prepare for the uncertainty of climate?
2. What time horizon should we plan for?
3. What factors will drive adaptation?
4. What is the Return on Investment in adaptation?
5. Who owns the Climate Risk?
6. How is resilience incorporated into contracts?

# Acknowledgments

Arup has conducted the following research in coordination with the World Bank Transportation group and associated personnel. The main authors of this report are **Lisa Dickson** (Boston) and **Yana Waldman** (San Francisco). Considerable additional input was provided by Arup staff globally:

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# Methodology

In order to understand the drivers of climate adaptation and barriers to resilience implementation, the World Bank is conducting research around trends and best practices in roadway operations contracting globally. Interviewing industry specialists in a diverse set of roles has provided varied risk perspective, while reviewing global guidelines has provided unique implementation techniques and approaches.

Table 1: Contributors

| **Role** | **Organization** | **Contributor** | **Country** |
|---|---|---|---|
| *Investors/ Funding Partners* | German Development Agency | Jeanine Corvetto | Peru |
| | Asian Development Bank | David Ling | Philippines |
| *Governments/ Project Sponsors* | Ministry of Transport | | Colombia |
| | National Roads Administration | | Mozambique |
| *Developers/ Contractors* | Opus | | New Zealand |
| | Cintra | *Confidential* | Spain |
| | Laing | | UK |
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| | Willis Towers Watson | Rhys Newland | UK |
| | Resilience Analytics | Paul Chinowsky | US |

# 1 Introduction

Recent academic research has shown that climate change disproportionately impacts developing countries more negatively than developed ones. Findings from a study of climate impacts on road infrastructure, in particular, showed that the modeled impact on opportunity cost ranges from 1-7% for developed countries, including Italy and Japan, and 33-200% for developing countries, including Bolivia and Ethiopia[1]. This measure of opportunity cost compares the financial costs of disasters to the overall road network. This effect is particularly concerning when considering the sustainable development goals of the World Bank and the Member United Nations General Assembly which were adopted by the Asian Development Bank.

## 1.1 Objective

The objective of the state of the industry literature review is to determine the commercial environment for inclusion of climate change metrics in Performance Based Contracting (PBC). The study is looking to understand the appetite for reduced climate risk exposure as well as mitigation of these losses through appropriate risk allocation. In order to reach an educated position on the subject, the study aims to improve the industrywide understanding of climate change risks and implications, identify more effective risk allocation within PBCs and develop more accurate costs and paybacks for considering climate change.

## 1.2 Process

The review process included evaluation of standards in both 'mature' countries who are implementing PBCs as well as those developing programs to accelerate infrastructure delivery. Arup has collected and reviewed published literature as well as interviewed a range of industry specialist around the globe to understand the specific methodologies whereby climate change is being addressed.

Input from the diverse range of project participant roles included the concerns and opportunities perceived by funding partners, project sponsors, project investors and advisors. Common threads consist of a need for better education and understanding around actual economic implications experienced by all project participants, including the public, which is typically carried by the local government. Accurate cost benefit analysis can only be calculated once all of these factors are included. The takeaway from these conversations included a need for new commercial solutions and better utilization of evaluation tools that are available in the PBC field.

[1] Amy Schweikert et al., Climate Change and Infrastructure Impacts; Procedia Engineering 78 (2014) 306-316

# 2 Background

Climate change affects roadway performance in two ways: immediate term and long term risk. In the immediate term, extreme events are arising more frequently and with greater intensity than what has been observed in the historical record. This sees an increase in 'emergency' activities—where the risk is carried by the client—even though there could be scope in some instances to have had the risks at least partially shared with the contractor. The long term climate change impacts are more nuanced and these may, in part, potentially be subsumed by the contractor's performance standards, the definition of which forms part of this assignment. Another aspect of long-term climate change is the way it may impact the design of infrastructure, where design of improvement or new infrastructure, which is often part of the responsibilities assigned to the contractor entity under PBC.

Changes in climate and weather are linked over the long term, but no single weather event can specifically be attributed to a changing climate. Extreme and high impact weather events disrupt service, damage expensive infrastructure, and necessitate more frequent maintenance. Transport agencies must manage both the rising costs of extreme weather as well as the public's expectation of rapid transportation system recovery following these events. This is likely to put more pressure on the organization, require new management activities, modify operational procedures—particularly maintenance contracting strategies – expand staff training, and increase emergency response procedures. More frequent and more severe extreme events, and changes in climate may exacerbate the impacts.

## 2.1 PBC

With PBC contracts[2], which are used both for constructing new works and for long-term maintenance across a number of sectors, the contactor takes on the responsibility and risks associated with design, construction, and ongoing maintenance to meet performance standards, which are linked to payments. A key aspect of PBC type projects is clearly allocating risks between the employer and contractor depending on who is best placed to manage the risks. Another key feature of such contracts is long term duration of contracts, in many instances for 10-20 years.

Some of the key challenges associated with PBC include the development of robust, agreed-upon metrics that can be standardized, easily quantified and measured. There is a degree of predictability that is also required to allow both the owner and contractor to be able to accurately forecast the overall risk over a given period of time. Aspects such as climate change which introduce uncertainty into this equation present a challenge. However, the issue is larger than just the uncertainty of that risk but also involves the overall transparency of that risk, whether or not it is clearly identified, who owns that risk and whether or not there is intentional (or unintentional) transfer of that risk during the project's life span.

It is critical that climate change be properly considered in PBCs because failure to do so may create biases when comparing PBCs over traditional of contracting methods.

[2] Including public-private partnerships, private finance initiatives or other forms of long-term management and concession contractual schemes

## 2.2 Climate Uncertainty

There is uncertainty in all aspects of PBC as is the case for any sort of exercise which requires projecting possible futures and developing metrics to measure success across a dynamic landscape. These uncertainties could include demographic and development shifts, funding and financing considerations, governance aspects, political considerations, economic stability, the projected use of the facility by future users and the overall relevance of that transportation facility to future community needs (for example, will the advent of autonomous vehicles redefine the transportation system in the same way that cell phones redefined the supporting telecommunication systems and inclusiveness in developing countries).

These have been addressed through a number of different instruments including clauses related to force majeure, such as acts of God and political instability. With P3 types of endeavors, due diligence is conducted up front to reduce some of that uncertainty with regard to projected ridership, funding and financing structures. Similar parallels exist within the arena of climate change work where future climate impacts are projected across a variety of time horizons and impact types to general "possible futures." For example, GCMs are used to assess potential shifts in precipitation based on a range of emission scenarios and future time slices, thereby providing a range of likely futures that take into consideration both the project increase in intensity and frequency of storm events (e.g., the current 24-hour, 100-year design storm becomes the 24-hour, 10-year design storm in 30 years) under a variety of carbon scenarios (e.g., A1F1, B1, A1B) and future time slices (2030 versus 2070 projections).

There is also an owner-informed aspect in all of this that relates to their risk tolerance for different aspects of their system and/or portfolio. For example, is the asset something that will have minimal consequence if it failed (and therefore the focus is more on repair and recovery) or are there significant consequences which will require considerations related to sufficient adaptive capacity or minimizing the risk altogether. There have been significant industry best practices developed over the past several years to address this translation of climate risk into design criteria and guidelines. In the end, however, it is the owner/investor (in this case, the World Bank) that determines the consequence of failure and overall risk tolerance at both the portfolio and asset levels.

## 2.3 Adaptive Solutions

With Design-Build contracts, the contractor is given flexibility in approaching a particular project (alternative technical concepts) but also assumes significant risk with respect to liquidated damages and other financial disincentives (which are sometimes balanced with incentives). These damages are based on industry-accepted risk profiles which have arisen from decades of design expertise and experience with the assumption that most of the influencing aspects (i.e., political, economic and natural processes) will continue to operate in a predictable and somewhat static manner. These industry standards are captured in very technical legal language which identifies risks with specificity and assigns values to lost time, underperforming products and other potential cumulative and foreseeable events.

The concept of ATC might be a possible way in which to address climate resilience within PBCs. It would allow the Bank to stipulate the expected performance metrics for particular climate impacts (for example, the project must be designed to account for extreme precipitation and heat events; the Bank would detail the extent of those events). It is then incumbent on the contractor to determine how to best address those project requirements for that particular geography, project type, community, etc.

The unstated assumption in all of these contracts is that the climate remains “as is” and is only infrequently punctuated by extreme events (often ascribed to “acts of God’).

## 2.4 Return on Investment

One of the fundamental challenges in the economic valuation approach is the current disconnect between the time horizons used by the larger investment world (often on the order of 3-5 years in the private equity realm and potentially longer – 10-30 years – in the development bank world). There have been some recent attempts to solve for this through the concept of resilience bonds (although these projections still rely heavily on past events to inform overall risk) and the more recent work of Goldman Sachs with the issuance of 100-year resilience bonds for DC Water in Washington, D.C.

Being able to value the benefits of resilience across the life expectancy of the asset is absolutely essential to fully capturing the ROI and to drive the larger economic discussions around “why.” The current disconnect between the investment’s community’s expected return of investment over a 3-5-year span (which is admittedly longer with entities such as the World Bank) and the actual life expectancy of that particular transportation facility (which often ranges from 50-75 years) means that the investment in resilience is completely undervalued for these projects.

**Financial Impact**

It is necessary that projects include amplified measures of value to offset increased developer costs. These opportunities can be gains for the developer, the community or the local government. In order to better calculate true value of opportunities and impacts, there needs to be better quantifiable understanding of potential business and social impact losses. Investment decisions will be calculated inappropriately until this holistic understanding of climatic impact is calculated.

# 3 Contract Stakeholders

There are several key drivers which motivate each of the stakeholders within a roadway operations contract but these are different for the specific parties involved. With regards to the impact of climate on roadway operations, we consider the Stakeholders with their associated Performance Criteria:

1. Developers
    a. Concern is **Asset Functionality**
    b. Driver Increased functionality of Roadway network or other asset type
2. Governments
    a. Concern is **Threat Reduction**
    b. Driver is Reduction in climate impact on local community or region
3. Investors
    a. Concern is **Economic Impact**
    b. Driver is Financial benefit of Asset on community or region
4. Insurers
    a. Concern is **Value for Money**
    b. Driver is Exposure reduction per dollar spent

## 3.1 Adaptation Drivers

The Performance Criteria and economic drivers of each stakeholder come with some measurable KPIs playing directly to those associated drivers. The following shows some of these potential areas of measurement to achieve each stakeholder's objectives.

1. Asset Functionality
    a. Availability Performance
    b. Service Performance
2. Threat Reduction
    a. Business Downtime
    b. Loss of Life
    c. Environmental Damage
3. Economic Impact
    a. Toll Revenue
    b. Business generation
4. Value for Money
    a. Asset Values
    b. Repair Cost Estimates

## 3.2 Stakeholder Input

In order to establish a baseline of current practice and knowledge on how climate change is incorporated into transportation projects, the World Bank is seeking to obtain insights on key issues that grantors/owners, contractors, financiers, and other stakeholders face. The key objective is to determine the challenges each subset of the industry has faced and what factors enable successful inclusion of climate change preparation in roadway development.

The team interviewed representatives from government and funding agencies as well as specialists in the fields of PBC, insurance and climate change adaptation around the globe to understand the obstacles faced by this emerging industry. The contribution of each participant is summarized below and individual feedback forms are included in Appendix B.

### 3.2.1 Developers (private partners)

The first party to shoulder the impacts of climate are the developers and operation contractors responsible for maintenance of the roadways. The costs associated with recovering from storm events and aggravated wear and tear associated with temperature fluctuations carry as budget overruns and eventually eat into project profit.

One view is that current contractors working in emerging markets lack accounting for weather and events that are likely to occur although unpredictable. In other words, the definition of extreme events and force majeure encompasses anything that currently disturbs the construction and running of an asset. The concept of quantifying the definition of what is actually force majeure may enable separation of standard climate and increasing weather events.

Contractors are unmotivated to bid on projects with such high levels of uncertainty and will be further discouraged by increased risk ownership experienced if the safety net of government bailouts are eliminated. The solution in this case will require education on the value of resilience.

### 3.2.2 Governments (public partners)

When the contingency budgets for storm repairs, increased drainage maintenance and unforeseen conditions have been exceeded, the regional government and asset owners are hit with additional service requests. While the goal of PBC is to transfer the risks associated with asset operation to developers, the threats may be outside of the control of the developers responsible for the assets.

One of the major issues raised has related to risk ownership for threats posed by offsite causes such as poor land use planning. This includes problems such as increased runoff from unplanned urbanization to debris flows resulting from irresponsible agriculture and natural resource management. Mitigation of these threats by the private developer is near impossible resulting in necessary involvement of government entities.

### 3.2.3 Investors (funding partners)

Increased operational costs resulting from escalating climate impacts leads to reduced project profitability. Projects run the risk of becoming non-viable or failing, resulting in borrower default. Funding partners see increasing exposure to the risk of losing their investment in assets that are heavily damaged or underutilized to the point of no longer being profitable or worth maintaining.

### 3.2.4 Insurers

Projections indicate that insurance providers will be forced to increase insurance premiums or decline coverage to high risk assets if they hope to stay profitable. When these providers increasingly experience claims as a result of intensifying climatic events, they will need to balance these.

## 3.3 Takeaways

- The value of resilience needs to be understood globally by developers and investors.
- Funding Partners need to make resilience investments profitable for owners and investors.
- All parties need to understand the real economic impacts of climate change events
- Governments should develop community benefit metrics linked to roadway resilience
- All parties need to determine what elements of roadway resilience

# 4 Industry Standards

While, international engineering standards as a whole have not yet adopted official language around climate change adaptation planning, many leading organizations are in the process of conducting research and publishing position papers on the topic.

The selected documents have been reviewed to understand potential for integration of climate consideration into a PBC model where extreme weather impacts held corresponding performance indexing. The chosen Standards and Guidelines aim to include diverse global perspectives focused around the following subjects:

(1) Roadway design and maintenance

(2) Performance based contracting

(3) Risk assessment and allocation

(4) Resilience Incentives

## 4.1 Design Guidelines

There is currently very little consideration of climate resilience in any published design guidelines globally. The typical guidelines follow event-based criteria that do not make considerations for fluctuations in climate hazard through the lifetime of an asset. Design standards have not actively addressed climate but many have increased the required design event from 50-year frequency to 100-year frequency. Even these progressive standards are static and backward-thinking, using climate data from the last 100 years. In order to appropriately plan for the next 50-100 years of storms, design standards need to adopt adaptive requirements.

Table 2 Climate Consideration

| Organization | Document |
|---|---|
| USDOT Department of Transportation | **Climate Adaptation Plan Ensuring Transportation and Infrastructure System Resilience** |
| USFHWA - Federal Highway Administration | **Building Climate Resilient Transportation** |
| AASHTO - American Association of State Highway and Transportation Officials | **California Department of Transportation: 2015-2020 Strategic Management Plan** |
| Colombia Ministry of Transport | |

### 4.1.1 USA Case Study: Climate Change & Extreme Weather Vulnerability Assessment Framework

This 2012 Guideline for transportation agencies interested in assessing their vulnerability to climate change and extreme weather events outlines key downtime indicators associated with climate change events. Development of this guideline focuses on assessing vulnerability areas of transportation assets to climate threats to understand failure points at varying levels of impact.

The three step assessment process aims to identify measurable downtime indicators at multiple loss level scenarios by determining project specific vulnerabilities. The process is outlined below.

1. Define Scope
    a) Identify Key Climate vulnerabilities (impacts of concern, sensitive assets and thresholds for impacts)
    b) Articulate objectives (motivation, target audience, products needed, level of detail)
    c) Select and characterize Relevant Assets (type, existing vs planned, data availability)
2. Assess Vulnerability
    a) Develop Information on Asset Sensitivity to Climate
    b) Collect Data on Assets
    c) Develop Climate Inputs for the Vulnerability Assessment
    d) Identify and Rate Potential Vulnerabilities
    e) Consider Adaptive Capacity
    f) Incorporate Likelihood and Risk

3. Integrate into Decision Making
    a) Incorporate into Asset Management
    b) Integrate into Emergency and Risk Management
    c) Contribute to Long Range Transportation Plan
    d) Assist in Project Prioritization
    e) Identify Opportunities for improving Data Collection, Operations or Designs
    f) Build Public Support for Adaptation Investment
    g) Educate and Engage Staff and Decision Makers

Downtime indicators developed form the study are shown below:

| |
|---|
| **Complete Failure**<br>Results in total loss or ruin of asset. Asset *may* be available for *limited* use after at least 60 days and would require major repair or rebuild over an extended period of time.<br>“Complete and/or catastrophic failure” typically involves:<br>Immediate road closure.<br>• Travel disruptions.<br>• Vehicles forced to reroute to other roads.<br>• Reduced commerce in affected areas.<br>• Reduced or eliminated access to some destinations.<br>May sever some utilities. May damage drainage conveyance or storage systems. |
| **Temporary Operational Failure**<br>Results in minor damage and/or disruption to asset. Asset would be available with either full or limited use within 60 days.<br>“Temporary operational failure” typically involves:<br>• Temporary road closure, hours to weeks.<br>• Reduced access to destinations served by the asset.<br>• Stranded vehicles.<br>Possible temporary utility failures. |
| **Reduced Capacity**<br>Results in little or negligible impact to asset. Asset would be available with full use within 10 days and has immediate limited use still available.<br>“Reduced capacity” typically involves:<br>• Less convenient travel.<br>• Occasional/brief lane closures, but roads remain open.<br>• Some vehicles may move to alternate routes. |

## 4.2 Performance Metrics

Performance-based contracting has been developed around a robust set of engineering- and construction-based industry standards that have been developed over decades of project-based work and academic studies. Climate change itself is still an emerging field with one of the primary challenges being that it cannot be derived from past events or data. At best, past data provide a benchmark; however, they do not provide a reliable proxy for future events. The uncertainty of climate change is also constantly evolving in the midst of increased global warming and its concomitant changes in the environment (e.g., rapid ice loss, increased severity of droughts).

The implementation of a Performance Metric approach allows for attention to changing asset exposure and variable usability conditions due to climate impacts but still do not connect these to cost of inaction. There are currently no published PBC guidelines that include provisions for climate related deterioration of assets. The mechanisms in PBC guidelines however, lend well to consideration of climatic events as they determine roadway performance based on daily usability and availability. This in turn requires developers to consider reasonable risk exposure over the term of the contract.

Table 3: Performance Metrics Considering Climate

| Organization | Document |
| --- | --- |
| US Transportation Review Board | **Performance Based Contracting for Maintenance guidelines** |
| AustRoads | **Impact of Climate Change on Road Performance: Updating Climate Information for Australia** |
| Highways England | **Strategic Business Plan – 2015-2020** |
| **The World Bank** | Output & Performance Based Contracts |
| | Good Asset Management |
| | Preservation and Improvement PBC |

## Case Study: Intercity Express Programme

The Intercity Express Programme (IEP) contract was for the design, build and maintenance of a new fleet of around 100 trains, commencing operations in 2017 and for a 27.5-year contract length. The contract was based on a PPP / PFI contract type (the first to be applied to rail rolling stock in the UK). The deal was worth some £5.7bn.

In common with most PFI / PPP contracts, the contractor was responsible for the availability and reliability of the rolling stock over the contract length. This included resilience to climate change and extreme weather.

**Performance Requirements**

The contract included specific reference to the UK Department for the Environment and Rural Affairs 'Climate Change Scenarios for the United Kingdom – The UKCIP02 Specific Report, April 2002'. The IEP trains must maintain full functionality in the event of all climate change scenarios stated in the report (including the "high emissions" scenario).

Additionally, one of the routes that the trains would operate on passes close to the sea for a stretch of several miles. This area has historically been subject to storms and high waves, which had led to malfunctions on previous train fleets, and which are likely to increase in frequency and magnitude in future. For these reasons, the contract also included a requirement to maintain full functionality during and after exposure to salt water spray and such and a requirement that exposure must not cause degradation of equipment.

Finally, the contract also included requirements for the trains to maintain full functionality during and after running through floodwater and snow (up to a depth of 100mm and 300mm respectively).

## 4.3 Costing Resilience

Many recent studies that have started to ascribe value to climate resilience. Examples of this work can be found at the macro-economic scale (e.g., the Sterns report, the Task Force on Climate-related Financial Disclosures), the country scale and regional scales (e.g., Larsen et al., 2008 – Estimating Future Costs for Alaska public infrastructure; Schweilkert et al., 2014 – Climate change and infrastructure impacts: comparing the impact on roads in 10 countries through 2100) and at the system level, project and client-specific level (e.g., https://www.rssb.co.uk/research-development-and-innovation/research-and-development/research-project-catalogue/t1009). In addition to economic and financial indicators, there has also been an effort to incorporate social and environmental values

At the project-specific level, our experience has been that the most persuasive and broadly-accepted arguments are based on the economics of resilience. This can include a valuation based on the ROI associated with decreased maintenance costs, less overall downtime or with the ability to structure projects in a certain way that would make them attractive to funding and financing by third party entities (e.g., climate bonds).

Table 4 Climate Risk Quantification Studies

| Organization | Document |
|---|---|
| World Bank Group | Decision Tree Framework |
| NZ Transport Agency | Establishing the Value of Resilience |
| Resilient Analytics | The Infrastructure Planning Support System (IPSS) |

### 4.3.1 Case Study: FHWA Model

Industry standards do exist within transportation that can be used to model a different approach. For example, the FHWA requires that selection of bridge design alternatives take into account not only the upfront capital costs associated with the construction of that structure itself, but also the overall maintenance and operational costs associated with keeping that bridge in working order for the next 50-75 years. This forces the decision makers to take a longer-term look at risk that spans the life expectancy of the structure itself and often results in the selection of bridge designs that might be more expensive to construct but whose savings in the overall M&O cost validate that decision.

Parallel arguments could be made for climate impacts. While the present-day climate might not result in immediate impacts to the transportation facility, future impacts – some which may occur as early as a decade from the construction – could significantly impair how that facility functions. Not only are the physical impacts something that need to be considered (as well as the costs associated with repair and recovery) but the bigger and often more important drivers relate to the loss of business continuity, access to critical services both during and following extreme events, as well as the cumulated impacts of longer-term stressors (e.g., the steady increase in temperature, sea level rise, etc.). The FHWA model could easily be adapted to account for these considerations in transportation design and funding decisions.

### Case Study: Using the IPSS for Comparing the Impact on Roads

The focus of this study by the Institute of Climate and Civil Systems (2014) includes ten geographically and economically diverse countries and the impact of 54 distinct AR4 Global Circulation Model (GCM) scenarios of future climate change on their existing road networks. The analysis looks at ten countries and analyzes their road maintenance, construction and adaptation policy behaviors.

The analysis was conducted using the Infrastructure Planning Support System (IPSS), which is a software tool that monetizes the opportunity and adaptation costs related to extreme events, incremental changes, and agency decision-making to enable a common comparison. The results show that higher income countries face higher costs due to more robust and complex network losses.

## 4.4 Financial Incentives

**How should Insurance premium deductions play a role?**

The disaster deductible concept is aimed at creating an incentive system for developers to undertake resilience-building activities throughout the lifecycle of roadway projects. In current World Bank contracts, there is typically a capped 10% contingency set aside for lump sum contracts to cover extreme weather events such as flooding, landslides, wildfires, etc. However, operators are reporting experiencing such high intensities and volumes of extreme events on a regular basis that this contingency is often insufficient to cover the term of the contract. Given the changing hydrologic regime in many World Bank geographies, it is not unreasonable for a single storm to completely deplete these small contingencies leaving project operators susceptible to unrecoverable financial losses from every other subsequent event.

Implementing a disaster deductible would convert the contingency lump sum contracts into an insurance model whereby developers would be responsible for contributing a custom amount, the deductible, for each disaster. The custom amount of the deductible payment would be based on the scale of the developer’s recent resilience-building activities. In the contracting phase, the funding partners and developers could negotiate what would be considered acceptable resilience-building activities with possible examples including drainage system enhancements to mitigate flood risk and vegetation management programs to mitigate wildfire risk.

On the other side, language around supervening events has enabled project participants to uniformly shift the risk of climate change related events to insurers who will continue to drive up premiums to cover exposure.

## Case Study: Adaptable Performance to Attract Investment

The Almanzora Autovía (A-334) is part of the "Plan for the Improvement of Accessibility, Road Safety and Conservation in Andalusia's Road Network". The inclusion of environmental aspects in the maintenance and operations programs reduces the risks arising from possible fines or penalties for non-compliance with legal environmental parameters. The disadvantage is that future incorporation of environmental indicators/criteria into the Concession Agreement may result in the need for additional economic resources. This also involves additional contractual commitments, with non-compliance that may result in potential sanctions, fines or other penalties. In addition to the costs of compliance with legal provisions, the concessionaire also assumed the cost of implementing ISO 9001, which was not mandatory by law but required by the contract.

The contract includes requirements for continuous improvement mechanism or update of the proposal for environmental indicators. Failure to comply with certain environmental standards and criteria covered by the law and specified in the EIS (Environmental Impact Statement), entails contractual penalties and, if applicable, legal penalties. The contract includes specific economic penalties for this type of non-compliance. In addition, overcharges caused by delays in obtaining permits and authorizations will be borne by the concessionaire. In addition, deductions may be made in the availability payments for breach of the indicators mentioned in the section "Analysis of the experience of the contract process and contract structure". By including this environmental criterion in the project, the concessionaire is able to more easily attract responsible financing. Thus, it will be able to attract funding from Multilateral Agencies.

# 5 Next Steps

## 5.1 Allocation of Risk

- The Bank should define and adopt a formal position and guidelines on PBC;
- How to ensure quality of PBC components in SSA?
- Building internal capacity/training Bank Staff to improve quality of advice to our clients;
- The benefits of aligning PBCs and Asset Management in SSA are significant;
- The Global Practice should initiate a comprehensive revision of sample OPRC document including among others, developing a suite of contracts for different models of PBCs, procurement approach to factor quality into selection process, and introducing standard ESHS requirements;
- How to prepare a fit for purpose Procurement Strategy for PBCs; and
- The need to learn from PBCs implemented outside the Bank, including other donors.

### 5.1.1 Risk Assessment

Current contracts are based on past data, which looks at the statistical return period of climate events using the occurrence of similar events within the historical record. The unstated assumption in all of these contracts is that the climate remains "as is" and is only infrequently punctuated by extreme events (often ascribed to "acts of God').

Extreme events are typically addressed through a number of different instruments including clauses related to force majeure, covering such as acts of God and political instability. With PBC and related lump sum contracting such as OPRC, due diligence is conducted up front to reduce some of that uncertainty with regard to projected usage, funding and financing mechanisms. Similar parallels exist within the arena of climate change work where future climate impacts are projected across a variety of time horizons and impact types to general "possible futures." For example, GCMs are used to assess potential shifts in precipitation based on a range of emission scenarios and future time slices, thereby providing a range of likely futures that take into consideration both the projected increase in intensity and frequency of storm events (e.g., the current 24-hour, 100-year design storm becomes the 24-hour, 10-year design storm in 30 years) under a variety of carbon scenarios (e.g., A1F1, B1, A1B) and future time slices (2030 versus 2070 projections).

### 5.1.2 Key Performance Indicators (KPIs)

The number of KPIs in a contract should remain low in quantity in order to ensure reasonable measurement. Suggested KPIs include the following.

**Measurable Roadway KPIs:**

- Availability – Reporting
- Service (delay times) – Minutes between exits
- IRI Pavement Roughness – Friction
- Settlement – Deformation
- Cracking – Number per area
- Surface Drainage – permeability/off flow
- Accidents – Reporting
- Fatalities
- Operations and Maintenance costs (includes insurance and repairs)
- CapEx costs (major repairs)

**Measurable External KPIs:**

- Business downtime
- Life Safety
- Revenue
- Environmental Damage (Use Equator Principles)
- Usage (if different from tolls)

### 5.1.3 Contract Changes

The existing roadway procurement process does not include climate change sensitive language outside of the necessity for screening in some cases. The decision to consider planning for changes in climate related risk (from a design or budget perspective) over the life of the project are at the discretion of the contractor performing the works.

1. Collaborate across similar World Bank projects to efficiently pull climate threat data.
2. Leverage Force Majeure language to shift risk and encourage developer resilience planning.
3. Consider community and public sector ownership of climate risk in risk models.
4. Include the return on investment of resilience measures within project plans to demonstrate saving to developers.

## 5.2 Valuation of Resilience

While there are a variety of considerations that go into how resilience is valued and implemented at a broad scale, we feel that there are three areas which would have particular relevance to the World Bank's PBCs:

### 5.2.1 Contract Requirements

Including mandatory requirements for climate resilience within the contracting procurement criteria and ranking respondents based on how well they have addressed this in the proposals. This will require that the Bank be specific as to what levels of climate risk the contractor will be designing towards – the process for which was addressed above (e.g., is it the 24-hour, 100-year event of today or 2030, etc.).

### 5.2.2 KPIs

Working with issuers of climate bonds to develop industry-accepted KPIs around transportation resilience in the same manner that they were currently developed for water resilience through the recent AGWA collaboration (of which the World Bank was a leader). We know that there is pent-up demand on the private equity side (including pension funds) to invest in brick and mortar types of projects related to resilience. The two key elements that will require additional development for this to occur include (1) investment –grade metrics that value both the direct physical impacts (including costs related to repair and recovery) as well as the value of business continuity and the ability to predictably and consistently deliver critical services; and (2) an agreed-upon third-party monitor to ensure that the projects are performing as specified. Entities such as The Nature Conservancy could prove to be valuable allies in this space.

### 5.2.3 Resilience Dividends

The need to address the somewhat unfounded assumption that including resilience within design will result in additional costs. We have industry examples where that is not the case. As one example, Partners Healthcare recently designed a state-of-the-art rehabilitation facility directly adjacent to Boston Harbor. Building on the lessons from Katrina, the final design incorporated a myriad of resilience design elements to ensure both patient and staff safety as well as continuity of services. The inclusion of those aspects only added 1% to the overall construction cost of that facility. We are confident that we can find other examples (with more of a transportation bent) that can further support this metric. The key here is that if resilience considerations are incorporated early on in the project development and design, their inclusion is integrative rather than additive and just becomes another design consideration within the larger development of that project. It is truly more of an educational issue (how do you think of resilience as a design criterion) rather than an actual costing challenge.

# Appendix A: Industry Standards Review

# A1 The World Bank Group

## A1.1 Decision Tree Framework

The guideline follows a Robustness based programmatic process for risk assessment of Water Infrastructure. The bottom up approach looks at performance of assets instead of published weather data projections. There is a heavy focus on the two issues of accurate risk assessment and effective risk management. The paper makes a case to reduce dependence on the general circulation models (GCM) as a means to determine risk exposure due to the climate change and proposes a stress test based approach.

The four step process aims to present scientifically defensible, flexible, cost-efficient tool to understand climate risks through a bottom-up approach that takes into account local realities and climate sensitivity.

1. Project screening to climate sensitivity
2. Initial analysis using simple project scoping to determine if climate is relevant compared to other project factors
3. Stress test using climate modeling and economic impact data
4. Risk management strategy to mitigate climate threats.

*Metric: Phased stress testing with multilevel Performance Indicators and Risk Thresholds*

## A1.2 Output and Performance based Road Contracts

Part of the WBG standard bidding documents for construction of roadways in developing regions. The Guidance Document aims to provide users with an alternative to traditional methods of procuring road reconstruction, rehabilitation and maintenance.

“Minimum road conditions and Service Levels are defined through output and performance measures, and these are used under the OPRC to define and measure the desired performance of the Contractor. In the OPRC, the defined performance measures are thus the accepted minimum thresholds for the quality levels of the roads for which the Contractor is responsible.”

Evaluated payment based on measured “outputs” reflecting the target conditions of the roads under contract (in other words: “what the roads are supposed to look like”), expressed through Service Levels.

The document is a template OPCR Contract which includes possible output and performance measures

| **Road User Service and Comfort Measures** |
|---|
| Road Roughness |
| Road and lane width |
| Rutting |
| Skid resistance |
| Vegetation control |
| Visibility of road signs and markings |
| Availability of each lane-km for use by traffic |
| Response times to rectify defects that compromise the safety of road users |
| Attendance at road accidents |
| Drainage off the pavement (standing water is dangerous for road users) |

| **Road Durability Measures** |
|---|
| Longitudinal profile |
| Pavement strength |
| The extent of repairs permissible before a more extensive periodic maintenance treatment is required |
| Degree of sedimentation in drainage facilities |
| Management Performance Measures |
| Delivery of regular progress reports to the Road Controlling Authority |
| Inventory updates and other data sharing requirements |
| Maintenance history (so subsequent tenderers can price the work). |

## A1.3 Good Asset Management

The guideline has been developed to reinforce that good asset management is an essential goal of any WBG investment in the on-going management of a road networks. Additionally, PBC is a proven method to drive the shift to achieve good asset management in various roadway types globally, including:

1. Unpaved roads PBC;
2. Paved roads in a generally poor-fair condition (DBMOT PBC); and
3. Paved roads in a generally good-excellent condition (Network Management PBCs).

The purpose of the document is to assist those new to the concept of PBCs to understand what they are, how they align with good asset management, and what the key issues are to consider before implementation.

**Potential advantages to PBCs**

- Potential reduction in costs
- Improved level of service
- The transfer of risk to the contractor
- Securing of an appropriate level of multi-year financing
- More innovation
- More integrated services
- Enhanced asset management on the part of both the PBC contractor and the Road Agency
- Ability to reap the benefits of partnering
- Industry Development
- Achievement of economies of scale
- Conscious focus of resources
- Expedited implementation of works
- A reduction (or elimination) in the level of corruption
- Reduced political intervention

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- Conscious focus of resources
- Expedited implementation of works
- A reduction (or elimination) in the level of corruption
- Reduced political intervention

**Potential disadvantages to PBCs**

- Potential disadvantages:
- A more costly procurement process for the bidders
- Increased complexity
- Potentially a longer procurement process
- Increased Cost of Data
- A reduction in competition
- Uncertainty: Uncertainty associated with long-term contracting relationships
- A potential loss of agency control and flexibility
- Shift in Control of Decisions

## A1.4 Preservation and Improvement PBC

The purpose of the document is to review the global experiences of PBCs, highlight advantages, and steps involved, and the results generated.

**General checklist of road assets**

Pavement surface; Shoulders; Slopes; Potholes; Open drainage system (paved and unpaved ditches and swales); Catch basins; Drains; Inlets; Curbs; Gutters; Sidewalks; Roadsides; Medians; Signs and traffic signals; Lighting; Fencing; Guardrails; Barriers; Attenuators; Street trees, shrubs and other plantings; Vegetation and aesthetics; Pavement markings; Pavement striping; Raised pavement striping; Highway and sign lights; Tunnels; Bridges; Rest areas, Over-height detectors; and Oil/grit separators on bridges.

**Performance indicators used in performance-based routine maintenance contracts with micro enterprises in Latin America**

- Culverts and inlets have to be structurally sound and clean to allow for the free flow of water;
- Surface drainage systems have to be structurally sound and clean to allow for the free flow of water;
- Vegetation should not exceed a height of 30 cm;
- No trees should obstruct traffic or pose a safety hazard;
- Compliance with the program to control erosion;
- Roadway and right-of-way should be free of litter, debris and road-kill;
- There should be no potholes;
- Cracks more than 3 mm wide should be sealed;
- Joints have to be sealed;
- Bridge structures should be clean;
- Bridge railings should be clean and well painted;
- Riverbeds have to be clean within 100 meters from the edges of bridges;
- There should be no obstruction of the roadway;
- Road and traffic signs should be clean;
- Milestones should be complete, clean and visible. Missing milestones should be replaced within 24 hours;
- Guardrails have to be clean, complete and visible;
- Road markers, road markings and horizontal road signs have to be clean;
- Responded in due time to emergencies;
- There should be no billboards within the right-of-way.

# A2 US Standards

## A2.1 U.S. Department of Transportation

**USDOT: Climate Adaptation Plan (2014) Ensuring Transportation and Infrastructure System Resilience**

In response to recent executive orders, DOT was required to submit a Climate Adaptation Plan (CAP) to address impacts to safety, state of good repair and environmental sustainability, this plan updates the 2012 CAP. The range of impacts from climate change may include roadway deterioration, flooding, limited waterway access and weakened structures, as well as reduction in life of capital assets and increase in operational disruptions. DOT identified three high-priority actions, focusing on Planning – ensuring that statewide and metropolitan planning addresses climate change, Asset Management – ensuring that modal administrations (FAA, FRA, FHWA, etc.) prioritize climate change impacts in asset management, Tools – developing tools, case studies, best practices and performance measures to support decision-making.

*Metrics:* No metrics directly provided – just contains a list of actions modal administrations have taken/are taking. Some documents referenced may provide metrics for each subarea.

## A2.2 FHWA – Federal Highway Administration

**FHWA**: **Building Climate Resilient Transportation**

The document outlines what agencies can do to build resilience with state and metropolitan case studies. The FHWA is formally responding to climate risks that threaten federal investment in transportation infrastructure by issuing an order committing the agency to integrating climate risk considerations into the delivery and stewardship of FHWA programs. The paper states that climate adaptation activities are eligible for FHWA funding, including vulnerability assessments and design and construction of projects or features to protect assets from damage associated with climate change. In addition, the updated emergency relief program guidance reflects climate resilience considerations.

The FHWA has also developed tools and guidance for systematic consideration of climate risks at transportation system and project levels. A new transportation law passed in 2012 requires states to develop risk-based asset management plans and to consider alternatives for facilities repeatedly needing repair or replacement with federal funding.

*Metrics: Clay soil shrinking during heat waves and drought (indicator of pavement cracking) – Austin, Texas MPO*

**FHWA: Mitigation Strategies for Design Exceptions (2007)**

Developed to provide designers with practical information on design exceptions and strategies that can be implemented to mitigate their potential adverse impacts to highway safety and traffic operations. Not relevant to climate adaptation metrics.

*Metrics: N/A*

### A2.3 AASHTO – American Association of State Highway and Transportation Officials

**California Department of Transportation: 2015-2020 Strategic Management Plan**

Caltrans, the state transportation agency for California, included a strategic objective in their Sustainability, Livability and Economy goal of the 2015-2020 Strategic Management Plan. The objective calls for the development of a Resiliency Score for climate change resiliency, system resiliency and financial resiliency and to consider asset management, emergency and risk management, climate change, sea level rise, vulnerability, adaptation, etc. While broad and vague, the Plan calls for the development of the Resiliency Score by December 2017. Additional work (discussed below) by the Agency references this target and appears to be researching processes to develop the score (including the NZTA example above).

*Metrics: To be defined throughout 2017.*

## A3 UK Standards

### A3.1 UK Department of Transport

**Transport Resilience Review: Update Report (2015)**

In 2014 the Secretary of State for Transport published the Government Response to the Transport Resilience Review – the response endorsed recommendations made in the review and set out expectations for the delivery of actions to improve the resilience of the transport networks.

*Metrics: none*

### A3.2 Highways England

**Strategic Business Plan – 2015-2020**

Highways England is the new Company set up by Government to operate and improve the motorways and major A roads in England. The vision is to create a smoother, smarter and more sustainable road network by 2040. The focus of the KPIs and metrics included in this report are primarily around improving efficiency, safety, economic factors and user communication. While some of these may be relevant to climate change and extreme weather events, there is no stated or specific tie to adaptation or resilience.

*Metrics: Safety, environmental, economic KPIs*

Highways England – 2016 – Design Manual for Roads and Bridges

Highways England – 2016 – Drainage Data Management System for Highways

Distillate – Designing a monitoring strategy to support sustainable transport goals

## A3.3 UK Committee on Climate Change

**Climate Change Risk Assessment Synthesis Report: priorities for the next five years (2017)**

The Committee on Climate Change (CCC) is an independent statutory body established under the Climate Change Act 2008 to advise the UK and devolved administration governments on setting and meeting carbon budgets, and preparing for climate change. The Climate Change Act requires the Government to compile every five years its assessment of the risks and opportunities arising for the UK from climate change.

*Metrics: Indicators of risk to transport sector*

**Progress in preparing for climate change: 2015 Report to Parliament**

The 2008 Climate Change Act requires the UK Government to conduct a Climate Change Risk Assessment and develop a National Adaption Programme (NAP). NAP covers twenty-four focus areas across six main themes: the built environment, infrastructure, healthy and resilient communities, agriculture and forestry, the natural environment, and business as well as a chapter on cross-cutting issues in local government. This report provides a progress update to Parliament on the actions identified in the NAP.

*Metrics: contains examples of resilience measures taken on infrastructure projects including HS2 and mode-specific agency/design standards*

# A4 Australia/New Zealand Standards

## A4.1 AustRoads

**Impact of Climate Change on Road Infrastructure (2004)**

The document provides an assessment of likely local effects of climate change for all Australia for the next 100 years. Identifies the likely effects on existing road infrastructure and potential adaptation measures in road construction and maintenance and reports on policy implications arising from the findings of the project.

## A4.2 New Zealand Transport Agency

**Measuring the Resilience of Transport Infrastructure (2014)**

The NZTA is in responsible for the state highway network and integrates with both rail and port services. The report was conducted to develop a framework and assessment tool to measure transport infrastructure resilience at various scales. Following a literature review, the researchers developed a framework and assessment tool and conducted a study using an implementation example.

*Metrics: Resilience measures focus on key principles of resilient networks (robustness, redundancy, safe-to-fail, change readiness, networks, leadership and culture). The principles are broken down into Measurement Categories. Each of these are ranked on a scale of 1-4, and* *these are translated into an aggregate score. The scoring and indicators appear to be based on qualitative assessments.*

**Towards Transportation Networks Resilient to Natural Hazards (2011)**

The Abstract provides lessons learned from recent events in New Zealand (Christ Church earthquake) and lays out a case for resilient transportation networks. The report notes that resilience needs to flow from the national level, in the form of a national strategy, down to the regional level, then to network asset strategies, emergency management and project development and design.

# A5 Latin American Standards

## A5.1 Guideline: Plan of Adaptation for the Primary Road Network

Study to identify, define and design environmental sustainability indicators, service levels and quality standards for projects developed under the Public Private Partnership scheme in the airport, road, health, education and Public buildings infrastructure field and their applicability in traditional public works projects. The objective of study is to obtain a sufficiently deep knowledge of the state of the art of the inclusion of indicators and/or aspects of environmental sustainability in PPP contractors internationally. The analysis of the environmental consideration of contracts has focused on the following aspects:

- Direct environmental obligations of the contract
- Environmental obligations that refer to legal provisions or that condition them at the discretion of a higher body
- Environmental obligations that materialize in the implementation of some sort of management system
- Risks to the concessionaire for the assumption of environmental criteria in the concession contracts
- Mechanisms for reviewing compliance with the contract (penalties, insurance and guarantees) containing environmental obligations.

# A5.2 Colombia Ministry of Transport

**Plan vías-CC – vías compatibles con el clima**

The document gives a general context of the road infrastructure sector and its relationship with climate change. The document evaluates the vulnerability and risk associated with the variability and climate change of the Primary Road Network.

- To make the road infrastructure resilient to climate change, it is necessary to include the Climate projections in new road design and maintenance works of the current ways.
- Due to "La Niña" Phenomenon 2010-2011, road closure and diversions caused losses around US$222, being the following departments the most affected.
- Also, damages in the road infrastructure, represented to the transport sector more than $3.23 trillion COP.
- According to IDEAM, the temperature is likely to increase throughout the national territory between 1 and 2ºC by 2040, and between 2 and 3 ° for 2070. For 2100, the temperature is likely to have increased by between 3 and 4 Andean region and the Atlantic coast. (Maps pg 12)
- The rise of sea level is another process of climate change that has been analyzed for Colombian territory. It is estimated to rise 0.3 m for 2030, and 1 m for 2100.
- According to the Study on the Economic Impacts of Climate Change in Colombia - EIECC (BIDDNP, 2014), in a conservative scenario, the transport sector will experience road closures in the network equivalent to 5.9% of the transit time, i.e. 21 days of closures per year between 2011 and 2100, in case the country does not take measures to avoid it.
- The Climate change requires to include new data projected to 20, 30 or 50 years in the design of roads as well as in technical designs or solutions for maintenance works, reconstruction and rehabilitation of existing roads.
- Designing better roads today involves reviewing the resources that are currently given for the stages of studies and road designs in the country. While in countries such as the UK this value reaches 45% of the total value of the works, in Colombia this value does not exceed 5% of the value total of projects.

# Appendix B: Industry Specialists Input Forms

| No. | Interviewees were asked the following questions but not restricted to these topics |
|---|---|
| 1 | What role does your organization fit into? (Government agency/grantor/owner; Contractor; Investor; Financier; Advisor; Other….) |
| 2 | What more specific contributions does the organization make in the roadway infrastructure life cycle / value chain (research, policy, design, construction admin/ supervision, operations, maintenance, concessionaire, other…) |
| 3 | From your viewpoint, what are the main threats related to climate (flooding/intense precipitation events, increase in drought conditions, rising sea levels, increase in hurricane intensity, higher heat, etc.) that effect operation of transportation infrastructure, especially roadways? How might these change in future? |
| 4 | Which of these climate related hazards are most likely to require retrofits or alterations in roadway design, construction, operation or maintenance over time? |
| 5 | What mitigation measures are being implemented in your organization and others to deal with these threats today? How is the approach adapting for future requirements? |
| 6 | How are climate projections or future climate scenarios developed within your organization? What industry standards do you follow? How has your organization defined and planned for extreme weather events and longer-term stressors like sea level rise in the past? |
| 7 | How does your organization (or others), currently allocate or manage risks related to climate change from a contractual standpoint? E.g. do you manage them in-house, are they passed down to other organizations, or passed upwards to government? |
| 8 | From your perspective, how could project risks, such as climate related impacts, be allocated most effectively through the life cycle of roadway projects? |
| 9 | Which parties are currently best suited to manage the different risks associated with climate change for any particular project? For example, do you think that the risks are well-known enough to be able to be priced efficiently by contractors? |
| 10 | Is there sufficient information available in early stages of the project development process to understand what the risks related to climate change may be for all of the stakeholders involved? What additional information might be needed to better define those risks, appropriately allocate ownership and estimate the cost of mitigation measures? |
| 11 | Force Majeure wording associated with contractual compensation events often results in Owner responsibility for climate risk if effects can be distinguished from normal wear and tear. Are there currently any practices in place to separate consequences (damage or downtime) resulting from climate change versus typical weather? This can be applicable to the owner or the operator. |
| 12 | In your experience, what contractual performance metrics, if any, have incentivized better allocation of climate related risk exposure? |
| 13 | Do roadway performance metrics enable builders and operators to properly understand, plan for and budget climate resilience measures? |
| 14 | What flexibility do PBC mechanisms contain that allows for improved mitigation of climate related roadway hazards? Are there changes that would improve this flexibility? i.e. must maintain minimum number of open lanes at all times |
| 15 | How could compensation events within the contracts be better defined in order to create equitable sharing of climate risk while still encouraging high performance? |
| 16 | Do you know of any contract mechanisms or variations processes that would secure continuous improvement in climate resilience? i.e. a mechanism to deliver improved resilience as more is known about the impacts of climate change over time? |

# B1 Investors - Funding Partners

## B1.1 Asian Development Bank

| No. | David Ling: Manages Transport Portfolio in Pacific Region |
|---|---|
| 1 | Development Bank - David's group looks after transport portfolio such as roads, maritime, aviation |
| 2 | Trade transportation and logistics, support government transport projects, government policy and masterplan. Policy on the national level, or masterplan for new ports. Project design, and construction supervision. O&M (tries to encourage PBC). Asset management. Capacity development. Concessionaire/PPP (tough to attract private capital there). PBC only for road maintenance contracts. Full contract includes road upgrade period (2 yrs.), notification (1 yr.), and PB road maintenance (2-5 yrs.) |
| 3 | An issue he tries to address (input driven). Address at the design stage and improvement stage at the civil works contract. Not really in O&M contracts |
| 4 | Design: projected sea level rise next 20 yrs., increase rainfall 20-30 yrs. (hydraulic model) informs drainage design, inform design and may increase costs. Encourage national and country standard – they use Australia and NZ standards |
| 5 | Same |
| 6 | Increase cost due to climate change measures – depends on the performance standards – ex) flood event (50 or 100 yr.), number of flood allowance, etc. |
| 7 | Tools: AWARE – anticipated climate changes (Global) and PACSSAP – Climate change association in Aus (2012-13) review of all pacific island countries estimate the climate change and rainfall. Apply to existing rainfall data then prob of % rainfall they would be getting |
| 8 | Same |
| 9 | Design bridges to overtop on some areas |
| 10 | Biggest hurdles: Risk the contractor (transfer CC risk to contractor) increase the cost of operations. As long as ADB make their IRR its fine. Contractor will price in the possibility of not meeting the CC provisions– will raise overall cost |
| 11 | Road maintenance (Just went through peer review): contractors are not interested in this type of work, they are interested in the improvement work. Only in it for the improvement work (rather than design it), then over the 5-year road maintenance they just pack up and leave. If we add a CC O&M they might bulk up the improvement work even more, but then also pack up and leave. Performance security of 10-30% |
| 12 | New design OK |
| 13 | Yes, same in Pacific Region. Example of triggering force majeure event) Solomon Island (2013) – 22km road (west Guadalcanal). Had 10 wet crossing and major bridges. 2015 had major floods and some crossings were washed out. Did not reach full design life. Ministry of Infrastructure Development (client/owner) |
| 14 | Metric: Improper land use leads to increased CC impacts – Seymour for example farmers will clear vegetation which results in landslides. In the PB Maintenance if there is a landslide the spoil needs to be removed. Logging: debris is thrown into the river and choke up bridges, esp. culvert and can't wash out to the ocean. Damming effect and doesn't matter how well the design for the culvert is and the bridge will overflow and wash out approaches |
| 15 | NA |
| 16 | NA |

## B1.2 German Investment Bank, Peru

| |
|---|
| **Sara Angelica Reyna Palacios** |
| **04/19/2017** |
| **Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)**<br>*GIZ is a German development agency that provides services in the field of international development cooperation* |
| Peruvian branch of the development agency |
| Development and implementation of financing mechanisms for projects that mitigate greenhouse carbon emissions |
| Peru is in a very early stage when it comes to including/considering climate change risk to the development and management of public infrastructure. |
| the recent flooding events in the coastal areas of Peru as a result of El Niño raised the need to think about how to adapt transportation infrastructure to extreme weather events. |
| NA |
| Peru has developed general risk assessment and risk management guidelines, which are not mandatory for project development. Within that general guidelines, climate change risk and adaptation are fleshed out. |
| i) Water (Water resources)<br>ii) Agriculture<br>iii) Fishery<br>iv) Forestry<br>v) Health |
| Peru's priorities in climate change adaptation, as published in the UN Framework Convention on Climate Change (UNFCCC), focus on people and their livelihoods rather than in infrastructure/logistics. |
| Any effort to truly incorporate climate change to the design/planning/implementation of infrastructure assets such as highways/roads must be through regulation. This means that the public sector, mostly the Ministry of Economy and Finance, would be responsible for adding climate change requirements to the existing project development framework (SNIP, by its acronym in Spanish). |

# B2 Governments - Project Sponsors

## B2.1 National Roads Administration, Mozambique

| |
|---|
| **Irene Simoes** |
| **2nd June 2017** |
| **National Roads Administration** |
| **Maintenance** |
| Government Agency |
| Research, policy, maintenance |
| Flooding/intense precipitation events, increase in drought conditions.<br>Studies indicates that due to Mozambican Geographical location the country is vulnerable to suffer these events and in future can be worst if mitigation measures are not taken in present. |
| Flooding/intense precipitation events |
| Actually studies to climate adaptation measures are being undertaken in order to recommend specifications construct or maintain resilient roads |
| Mozambique has approved a National Climate Change Strategy 2013/2025 and other related documents |
| The risks are quantified and the costs allocated in the contracts |
| The risks should be identified, quantified and allocated from the design stage and a budget to mitigate the risks at the maintenance stage. |
| In any type of contract including BOT the risks to a certain level of sustainability should be allocated to the contractor. If the risks became very high that can threat the viability of the project so sharing of risks should be considered. |
| No. all are considered as emergency situation. |
| This process is still under study in Mozambique, as the climate adaptation study in being elaborated, and the second phase will be a demonstration phase which includes roadworks. |
| The contract should stipulate a maximum percentage of costs for remedial works. I would propose 20/80, i.e., 20% maximum to contractor and 80% for the client |
| This process is still under study in Mozambique, as the climate adaptation study in being elaborated, and the second phase will be a demonstration phase which includes roadworks. |

## B2.2 Ministry of Transport, Colombia

| |
|---|
| **Juan Camilo Florentino Márquez Ospina** |
| **15/06/2017** |
| **Ministry of Transport** |
| Sustainable Urban Mobility Unit |
| Government agency |
| The Ministry of Transport is involved in almost all stages of infrastructure lifecycle, except construction itself. The Ministry, jointly with National Planning Department, defines road infrastructure needs and enables financing mechanisms and governance structures for its supervision. The Sustainable Urban Mobility Unit, where I work, is in charge specifically of urban roads and urbanism for Transit Systems. |

| |
|---|
| • Higher Heat (extra energy consumption inside buses for intra-cabin conditioned air)<br>• Intense precipitation (Lowering of passenger´s willingness to wait outside at bus stops)<br>• Flooding (Impact on buses operation velocity or frequencies)<br>• - Drought (water availability for cleaning and maintenance of motor fleets and infrastructure) |
| • Higher heat: new building materials seeking to reduce heat island effect on urban environments.<br>• Intense precipitation: Retrofit and expansion of sewage infrastructure to collect and conduct raining water.<br>• Prioritize investments on non-motorized transport (walking, cycling) for: i) promoting more resilient/flexible vehicles that may operate even on climate disasters (flood, i.e.); ii) avoiding dependency on motorized vehicles; iii) reducing urban areas dedicated to roads by protecting and enhancing natural drainage areas (grass, soft areas) |
| There are not very strict measures in place in order to reduce climate threats. Anyway, there are a couple of investment decision making instruments:<br>• Climate risks assessments are conducted on projects feasibility phase.<br>• Inclusion of climate adaptation criteria on detailed engineering designs.<br>• Contractual obligation for construction companies to implement Environmental Safeguard policies and mitigation measures. |
| The Ministry does not develop future climate scenarios. It takes as reference, climate scenarios developed by IDEAM (A specialized research Institute on Meteorology Hydrology and Environment) |
| It is not very common to include climate change risks in contracts for urban infrastructure (roads, stations, bus stops, sidewalks, etc.). In that cases when these risks are foreseen, contractors usually pass them downstream to builders. Anyway, it is possible to share high risks that may imply big budget modifications. |
| Decision makers as well as designers should assume climate risks, taking into account they should foresee impacts and identify mitigation measures. |
| Environmental agencies, Local Disaster Risk Management Entities and construction companies should be the best suited for manage these kind of risks. Nevertheless, this is not the actual scenario. Risk may be well known in some cases, but not well priced neither well allocated. |
| Not at all. It is hard to predict the type and dimension of climate change related risks because they are, essentially, unpredictable. Risk mitigation costs are also hard to estimate, but there could be accurate approximations using historical data on budget allocation for fixing roads affected by climate related damages. |
| It is almost impossible to differentiate “normal” weather/climate events from climate change, unless there were good hydrology, meteorology and climate time series (with consistent and homogeneous measurement methodologies) |
| I do not know what kind of roadway performance metrics are used for monitoring climate impacts. I supposed there should be measurements of drainage patterns, sediments on rain water collectors, local temperature, number and volume of slides, etc. |
| I have no experience related with PBC mechanisms used on urban road contracts. It should be more frequent on regional/national roadways. |
| Usually, contracts include “unforeseen costs” of about 2 - 6% of infrastructure direct costs. There could be a methodology for increasing this percentage depending on climate risk assessment, as a contingency fund, which may be reimbursable. Resources could compensate extra-investments for attending climate related damages. |
| No. I do not know. It seems to be more focused on concessionaries that could progressively improve infrastructure resiliency. A starting point could be an analogy with offsets markets for GHG mitigation actions: extra-tolls allowed for resilient roadway, for example… |

# B3 Developers – Operations Contractors

## B3.1 Opus - New Zealand Road Concessionaire

| |
|---|
| **Rowan Kyle** |
| **8 May 2017** |
| **Opus International Consultants** |
| Transportation Asset Management |
| Consultant – Engineering, Planning, Environmental |
| Design, supervision, research, management contracting. |
| Increased rainfall affecting road pavements through lack of drainage, flood / storm events damaging infrastructure, reducing availability. Sea level rise damaging low lying infrastructure through storm surges, inundation, reduced drainage capacity. Increased temperatures reducing lifecycle performance of surfacing materials. Storm frequency and/or intensity is anticipated to gradually increase over time. |
| Increased rainfall intensity will require retrofitting of culvert and drainage structures to increase their capacity. Improved drainage systems will be required to mitigate the impact of higher ground water conditions that might otherwise reduce pavement lifecycle. |
| Design of drainage structures takes into account predicted changes in rainfall intensity / return interval patterns. Design of transportation routes within coastal areas takes into account predicted sea level rise. |
| Information and predictions are obtained from national or international climate research organizations. Standards or policies from respective road controlling agencies and/or local authorities would be adopted where necessary. These would be incorporated into designs and/or maintenance plans. |
| Where the risk can be mitigated through design, construction and operational requirements they are passed down to the contractor / supervising consultant. Where the risk cannot be adequately mitigated due to physical or financial constraints it is passed up to the government. |
| Effective allocation is dependent upon the accuracy and reliability of the underlying data and information around the frequency and consequences of the climate change risk at the project level. The better these aspects are understood, then better decisions can be made around the responses and related costs. |
| Research and policy risk is best managed at the local or national government level. Design risk, asset lifecycle risk is best managed at the project level by the consultant / contractor, but only once the policy position and underlying research data is available. |
| This will vary in each location. Some countries will have reasonably good data, predictions and policies that can be used in developing adequate mitigation measures, and others will not.<br>Improved linkages between risk and benefits from increased investment will assist decision makers in determining the value for money equation and long term benefits. |
| Unaware of any specific clauses, as it may be difficult to distinguish the difference between background weather events and the impact of climate change over time.<br>A review of current contractual clauses around risk sharing is necessary to criticality examine if there is the need to rebalance the extent this is currently apportioned. |
| Definition of inclement weather and the number of days that have to be managed within the contractor's program before an Extension of Time can be claimed. Risk of damage from weather events carried under the contractor's / client insurance policies, and the value of any excess. |
| Not very well at this time. Metrics around network availability, asset lifecycle performance and investment planning do not adequately recognize the impact of climate change, as it masked by other more dominate factors (e.g. changes in traffic patterns and loading). The rate of change is either too slow, or is too hard to identify outside of background weather conditions and normal operational wear and tear. |

## B3.2 Laing - UK Road Concessionaire

Mark oversees Laing's PPP / PFI portfolio across a number of countries (including the UK, Europe, Australia, the USA, New Zealand, and Ireland). The company's portfolio is focused on the developed world, save for a small number of projects including a road project in India. Laing's investments include and large renewable energy (wind, solar, biomass) portfolio and a large transport portfolio, but also schools, hospitals, prisons and (more recently) broadband and electrical infrastructure. Laing focuses on greenfield projects.

Laing is generally a "taker" of a specification from government, and as such, plays a role in responding to a specification, rather than determining it. In Mark's experience, it is unusual to see a specific reference to climate change within the contract documents, and clients are generally not building in requirements for future climate change. This hasn't changed much during Mark's career (there hasn't been a recent increase in focus on climate change, for example). Authorities are increasing their political voice, so this may be more common in the future.

Perhaps an exception to this was the Dutch A6 road, there were incentives for the road to minimize carbon. Laing won on the basis of a carbon neutral road, which was achieved through renewable energy sources placed alongside the road. In this case, the bid was perhaps more expensive than the others, but won on the basis of value points scored in the evaluation on carbon emissions.

Laing are exposed to the risks of climate change to an extent. Business interruption insurance is held by Laing to be held for specific sectors relative to the specific investments it makes (e.g. for IEP trains, earthquake insurance was held as the trains were to be manufactured in Japan). Nevertheless, decisions on whether or not to make a claim would depend on the impact on future policy pricing, so Laing are exposed to it.

In many contracts, Laing are exposed to the risk of a general temperature rise, without carve outs such as force majeure. This includes, for example, maintaining a constant on-board temperature inside rail rolling stock. Nevertheless, some contracts do include carve outs for force majeure for extreme weather, such as a 1 in X event, and this seems to differ on a contract by contract basis. Mark hasn't noticed any difference in how this is treated over time.

Mark recommended John Daly at Marsh as a good contact within the insurance industry, for any in-depth queries in this space.

## B3.3 Cintra - Spanish Road Concessionaire

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| **18-05-2017** |
| **Cintra (Ferrovial Group)** |
| Concessionaire. There is a relevant interest in the long term to assess these risks. |
| It is a relevant and pressing issue for them and it is noticed as an opportunity given the fact the high amount of assets Cintra manages and the long-term period of management.<br>A methodology is currently under performance to assess projects. Cintra is generating internal tools for design phase to try to monetize and determine it taking into account the IRR.<br>It is more a threat for the IRR than an opportunity. |
| Climate Change is understood more as an opportunity.<br>There is little available information, and it would change CAPEX and OPEX results. Mobility patterns in 2060 are mostly unknown but costs are expected to grow in maintenance and slope stabilization. In any case we were told that they are collecting data from now on. |
| Flooding and drought. |
| The approach now is taken is case by case. Ferrovial group has a program to implement a future risk mitigation plan and a few people from the organization and its branches is involved. |
| The main issue is that scenarios are projections for year 2060 and we are not aware of the evolution and technology trends on road management by then.<br>Another of the limitations is the unavailability of many data to analyze them and extract conclusions such as relevant aspects like slope stabilization or cold waves.<br>No concrete and defined plans are performed. |
| No specific requirements have existed by today for Cintra. The analysis and the study of the climate change aspects are included within the Ferrovial strategy, with the specific objective of integrating it into the projects.<br>Lenders are more and more requesting the integration of these requirements, especially those that go further than the standard requirements.<br>Transforming risks or sharing them is very difficult. By today the risk is not being shared, it is assumed by the administration. |
| Planning how to include these inputs from the beginning in the new projects. Implementing measures and investments in the current assets. |
| Concessionaire and contractor branches of Ferrovial have different interests but it is clear they have the experience, data base and know how to manage this. |
| By today, designs are not taking into account the water return scenarios projected by 2060. This would make CAPEX costs too high. The design phase would be suitable to be taken into account for this. |
| There is no notice about this in the current contracts they had signed. |
| Lenders, especially multilaterals (EBRD and BID, etc.), are very clear on the requirement of indicators, although no agreed methodology exists. They put pressure on this issue.<br>The work they are performing is seen as an opportunity to take a stance and increase the IRR. |
| Establishing a baseline is needed to estimate CAPEX and OPEX to base on Climate Change and be able to make predictions. |

# B4 Project Advisors

## B4.1 ReFocus - Investment

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| **Shalini Vajjhala** |
| **6/1/17** |
| **Refocus Partners** |
| Advisor |
| ReFocus provides strategic advice to investors and asset owners around the return on investment surrounding resilience. |
| Flooding and Erosion not only damage actual assets and revenues but also reduce economic opportunity in surrounding areas by limiting access and collaboration. |
| NA |
| Climate risk is carried by the long term owners and owners that do not have the ability to unload assets such as cities and government agencies. |
| Climate adaptation costs should be accounted for with increased revenue streams generated through community benefit charges |
| Understand the risk exposure of all involved stakeholders, even those outside the contract to determine those best suited for ownership.<br><br>Risk exposure is on a sliding scale relative to probability of occurrence. |
| It is important to understand all of the risks associated with climate change such as business disruption and social disruption to properly account for exposure costs. |
| Design standards do not promote increased resilience because we need win/win scenarios. |
| Accurate Catastrophe modeling is key understanding loss avoidance and payout for resilience. |
| Cost premiums for climate adaptation should be accounted for with increased and separate revenue streams generated through community benefit charges. These require assets to perform protection functions for surrounding area in addition to service they are originally planned for. i.e. roadways that act as levees |

## B4.2 Willis Towers Watson - Insurance

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| ***Rhys Newland*** |
| **20th June 2017** |
| **Willis Towers Watson** |
| Project Risks Practice |
| Financial Services/Adviser - Insurance |
| Advising both Government and Contractor clients on risks, risk assessment, quantification, opportunities for risk transfer and insurance. Design and placement of insurance products and programmes to meet project risk requirements. |
| Flooding and flash flooding events have thus far caused the most losses of physical infrastructure on road infrastructure projects in general. However, drought/subsidence and sea level/storm surges have caused specific transport infrastructure issues in specific territory and specific project locations. This in turn leads to financial exposure to physical damage reinstatement, design changes/improvements, self-insurance requirements, lack of availability of insurance cover and enforced Capital Expenditure (by insurers to make the risk insurable). |
| Arguably all of them, but we would probably categorize two types of retrofit/alterations: First those issues/impacts/losses that may be fixable for Contract life of the infrastructure in one single refit encompassing new design standards, for example if annual temperature extremes are experienced/predicted to be much higher and this caused surface damage, it may be possible to resurface with different material to 'future proof' the infrastructure. Second, those issues/impacts/losses that are likely to re-occur unless either the infrastructure is constantly retrofitted, abandoned or totally redesigned, for example coastal erosion/storm surge/sea level rises leading to either constant repair of original infrastructure (e.g. original raised embankments) or installation and constant repair of retrofit risk management infrastructure (e.g. new sea walls) or the entire exposed section needs to be redesigned and rebuilt (e.g. elevated or bridge work reinforced). Insurance may cover original damage and repair (although not betterment) but would not fund total redesign works. |
| Modelling of the risk via actuarial and catastrophe modelling has become much more prevalent on an industry wide and territorial basis. On an individual risk basis, insurers will want complete technical risk assessment information, for example Flood Risk Assessments before considering the risk. If a specific risk is applicable to a specific asset class or territory, then insurers may produce risk guidelines or design standards to guide Contractors on what risk mitigation is expected. This can lead to guidance having to be complied with before the risk is considered. |
| Typically, the insurance industry is retro-focused and models future losses on past claims on an actuarial basis. However, climate change, especially the potential for rapid climate change and more frequent extreme weather events is changing this process. The industry reacts in two ways, first mapping of the most vulnerable areas based on location and asset values. Where high asset values are within risk areas then such modelling is more intense. For example, earthquake risk in Japan and hurricane risk in the South East coast of the USA are understood and modelled. This naturally results in design standards in high risk high asset value areas, such as structural design of buildings in earthquake zones. This is essentially impact modelling. Secondly the modelling of risk based on predictive science, which is much more uncertain and a newer discipline to insurers. Climate change falls into this category and insurers are working with scientists to try to understand scenarios to predict longer term exposure. |
| A large proportion of climate risks manifest themselves in physical damage. Physical damage is generally an insured risk. Insured risks are generally passed from the Government to the Contractor in long term contracts and transferred from the Contractor to insurers for a premium. However, insurance for operational assets is on an annual cycle and therefore subject to rapid change in terms of risks covered, premium levels and self-insured retention levels (excess/deductibles). |
| The annual availability and pricing of insurance makes the risk transfer subject to great uncertainty over the project life. PPP models have already recognized this by use of mechanisms such as Uninsurability and Insurance Premium Risk Sharing mechanisms in contracts. However, neither of these mechanisms currently reflects the potential need for large Capex spending on retrofit/retrodesign elements to satisfy insurers to keep insuring the risks at an economically acceptable premium. This area needs work to recognize that such risks will need to be in some form of risk share. |

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| Risk pricing based on the ability to transfer physical damage (and consequential revenue losses) to insurers is subject to change and can only be considered a short term mechanism. As insurers will not commit to longer than annual cover/price then the level of cover, price of risk transfer can and does change rapidly and does not suit a long term contract which fixes price and risk over a longer term. |
| Design will tend to be price sensitive at competition stage and therefore targets adequacy of design to current standards, risks already known. Climate change may call for a more robust view of design on a worst case basis with some ‘future proofing’ built into Capex spend. This will take a shift in attitude from both Contractors and Government and also potentially a change in procurement processes. Some form of risk priced modelling based on best case, likely case and worst case scenarios may be required to agree initial design parameters and future risks of overspend and retrofit also. |
| Not from an insurance perspective, currently climate risk impacts that result in physical damage are insured, including the consequential revenue protection, hence leaving Contractors in a no worse position, however this is likely to change if the risk frequency increases. |
| Uninsurability provisions and Insurance Premium Risk Sharing mechanisms may assist in allocating physical damage related risks. |
| Lack of sufficient data to model future risks hampers such processes. |
| Climate change risks are by nature reactive and evolving, therefore this may be difficult to place into a PCB framework and contractual penalty regimes would not effectively incentivize risk management of the unknown and/or unquantifiable future risks. |
| As above currently this is a difficult area which relies on a currently tried and tested risk allocation from Government to Contractor and transferred from Contractor to insurer. Uninsurability and premium Risk Sharing/relief mechanisms are already in place to mitigate insurance risks in many contracts. |
| We are unaware of any such contracts currently. |