






PIARC Activities on Climate Change Adaptation and Resiliency



Climate Change: From Desk to Road
 CEDR Call 2015 Climate Change – Final Conference
 November 19-20, 2018 - Utrecht, Netherlands



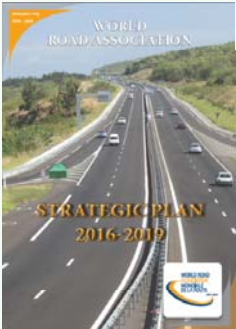
J. Krieger – Division Bridges and structural Technology, Federal Highway Research Institute (BAST), Germany




PIARC - Strategic Plan 2016-2019

The Strategic Plan for 2016-2019 sets the organization structure of the Technical Committees according to five Strategic Themes:

- Strategic Theme A - Management and Finance
- Strategic Theme B - Access and Mobility
- Strategic Theme C - Safety
- Strategic Theme D - Infrastructure
- Strategic Theme E - Climate Change, Environment and Disasters**



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PIARC - Strategic Plan 2016-2019




ST E - Climate Change, Environment and Disasters

- **TC E.1 Adaptation Strategies/Resiliency**
- TC E.2 Environment Considerations in Road Projects and Operations
- TC E.3 Disaster Management

The goal of this Strategic Theme is to increase resiliency and protect investments in transportation infrastructure from impacts of climate change events while lessening the impact of road transportation on the environment.


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Challenges for Owners and Operators of Roads

- Increase in traffic
- Ageing infrastructure (beyond design limits)
- **Climate Change and Extreme Weather**
- Disasters will continue to occur, whether natural or human-induced





*Procedures, Methodologies to ensure
availability, safety and security*

Resilience Management/Resilience Engineering (all-hazard)



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Climate Change



Key IPCC projections are that:

- The Earth will become warmer,
- Some regions will become wetter overall and some will become drier,
- Sea levels will rise and storm surge height will increase,
- Snow cover and the extent of sea-ice will reduce, and
- The frequency and severity of extreme weather events (such as storms, heat waves, drought and periods of prolonged and heavy precipitation) will increase.

These changes are set to have significant impacts on the design, construction, maintenance and operation of global road infrastructure.

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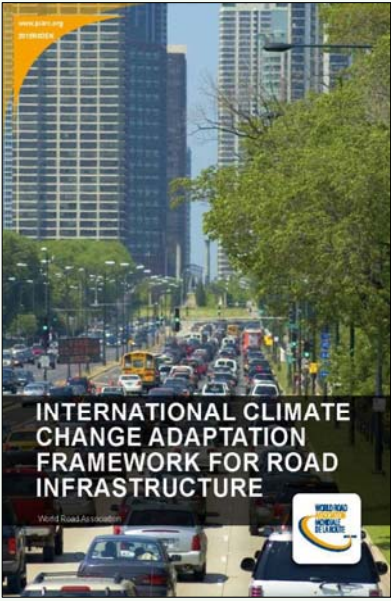
PIARC Adaptation Framework

Author(s): KIDNIE Murray; MARCHESE April; MARUNTU Cristina; MURPHY Helen; SEBILLE Robin; THOMSON Stephen
TOPLIS Caroline, AECOM Project Manager

Domain(s): Environment / Risk management




PIARC Ref.: 2015R03EN

ISBN: 978-2-84060-362-7



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PIARC Adaptation Framework

The framework guides road authorities through the process of increasing the resilience of their networks and assets through the following stages:

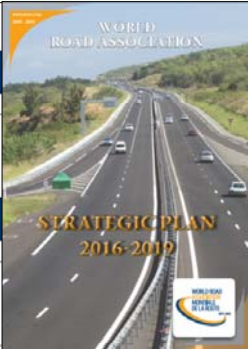
- Stage 1 - Identifying scope, variables, risks and data
- Stage 2 - Assessing and prioritising risks
- Stage 3 - Developing and selecting adaptation responses and strategies
- Stage 4 - Integrating findings into decision making processes

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PIARC - Strategic Plan TC E.1

TC E.1 Adaptation Strategies/Resiliency	
Issue E.1.1 Adaptation strategies to increase resiliency	
<i>Strategies</i>	<i>Outputs</i>
To investigate and disseminate information about current adaptation strategies to increase the resiliency of road infrastructure.	Report based on case studies
Issue E.1.2 Climate Change Adaptation Framework	
<i>Strategies</i>	<i>Outputs</i>
Refinement of the Climate Change Adaptation Framework (based on the Special Project developed in the 2011-2015 cycle) and follow-up of its implementation.	Report based on case studies



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Resiliency - Characteristics




A resilient system shows:*

- reduced failure probabilities,
- reduced consequences from failures, in terms of lives lost, damage, and negative economic and social consequences,
- reduced time to recovery (restoration of a specific system or set of systems to their "normal" level of functional performance)


* Bruneau, M.; Reinhorn, A. - Exploring the Concept of Seismic Resilience for Acute Care Facilities

Motorway bridge in the course of the A57




Motorway bridge in the course of the A57






Wiederherstellungskosten (EUR)	Planung Behelfsbrücke	geschätzte Kosten: 3,5+6,5 Mio. EUR
	Planung Neubau	
	Abbruch der zerstörten Brücke und der restlichen Unterbauten	
	Neubau der 3 Behelfsbrücken	
	Rückbau der 3 Behelfsbrücken	
	6-streifiger Ausbau der neuen Brücke	
	Verwaltungskosten	
Gesamtwirtschaftliche Kosten (EUR)	Kosten der Mehrreisezeiten während der Vollsperrung	30.663.613
	Kosten der zusätzlichen CO ₂ - Emission während der Vollsperrung	207.485
	Kosten der zusätzlichen NO _x - Emission während der Vollsperrung	6.643
	Kosten der zusätzlichen PM - Emission während der Vollsperrung	110
	Kosten der Mehrreisezeiten während der Teilspernung	22.919.624
	Kosten der zusätzlichen CO ₂ - Emission während der Teilspernung	-1.120.524
	Kosten der zusätzlichen NO _x - Emission während der Teilspernung	-16.037
	Kosten der zusätzlichen PM - Emission während der Teilspernung	-585
Summe gesamtwirtschaftliche Kosten (EUR)		52.660.329



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Resiliency – Definition* (one of many)

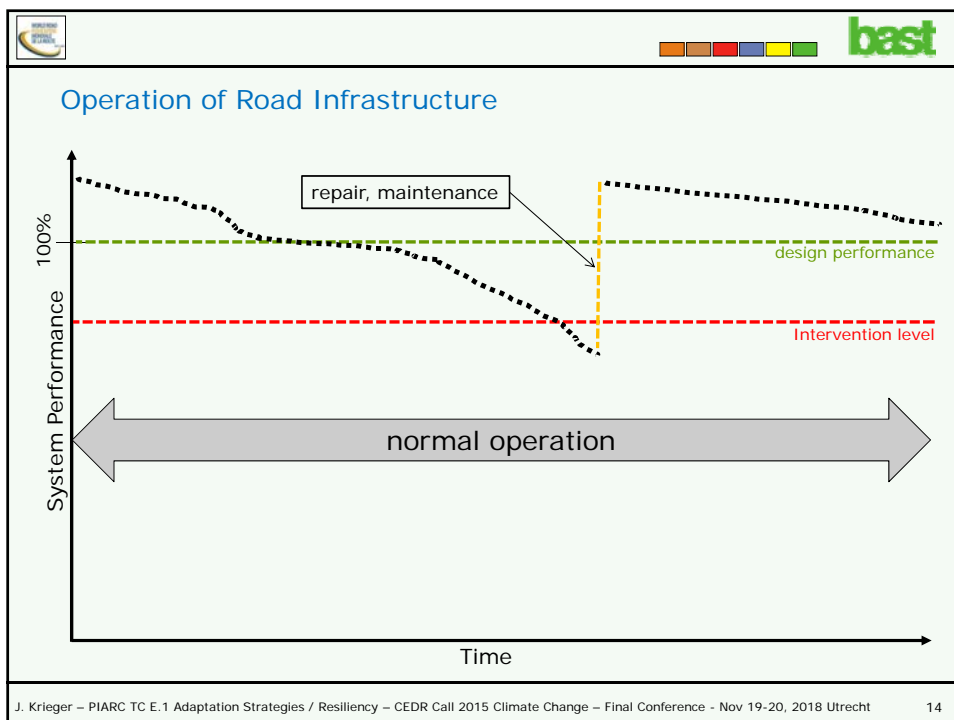
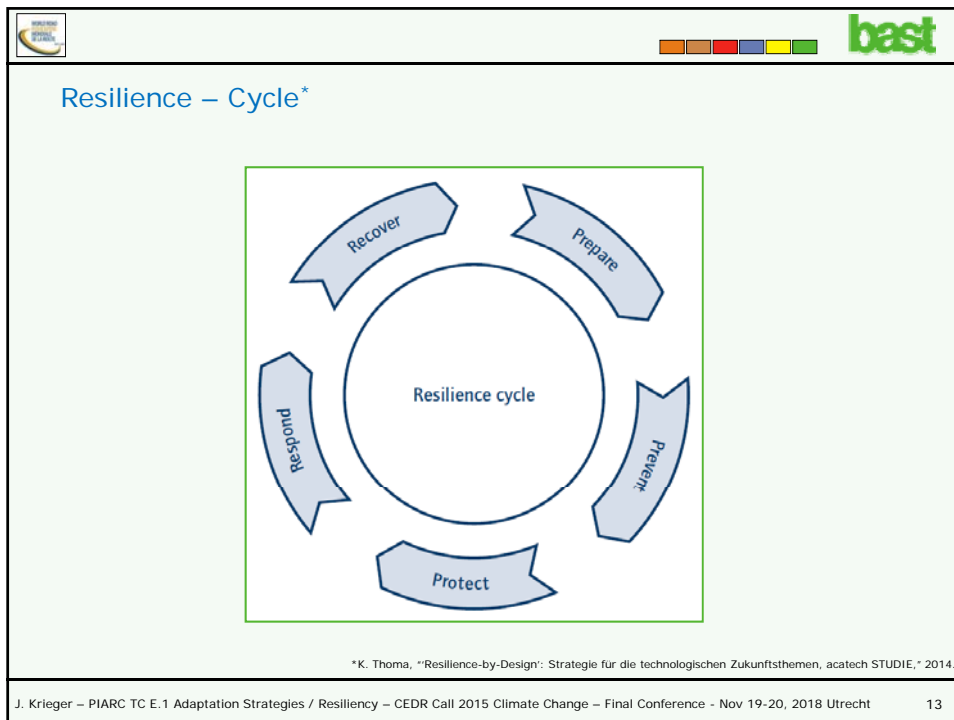
Resilience is the ability to repel, prepare for, take into account, absorb, recover from and adapt ever more successfully to actual or potential adverse events.

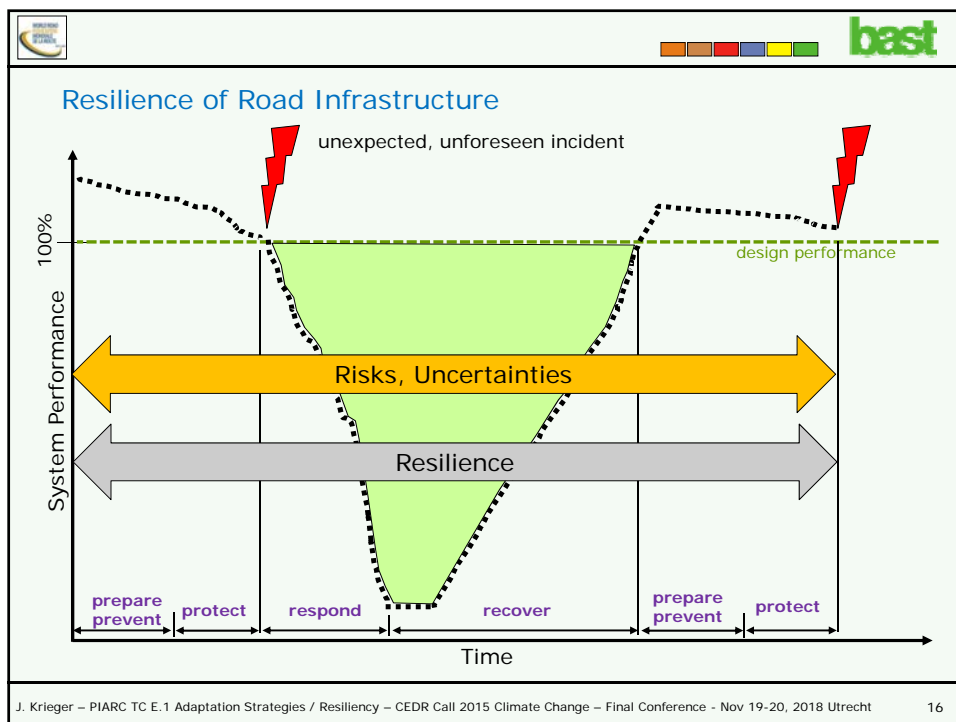
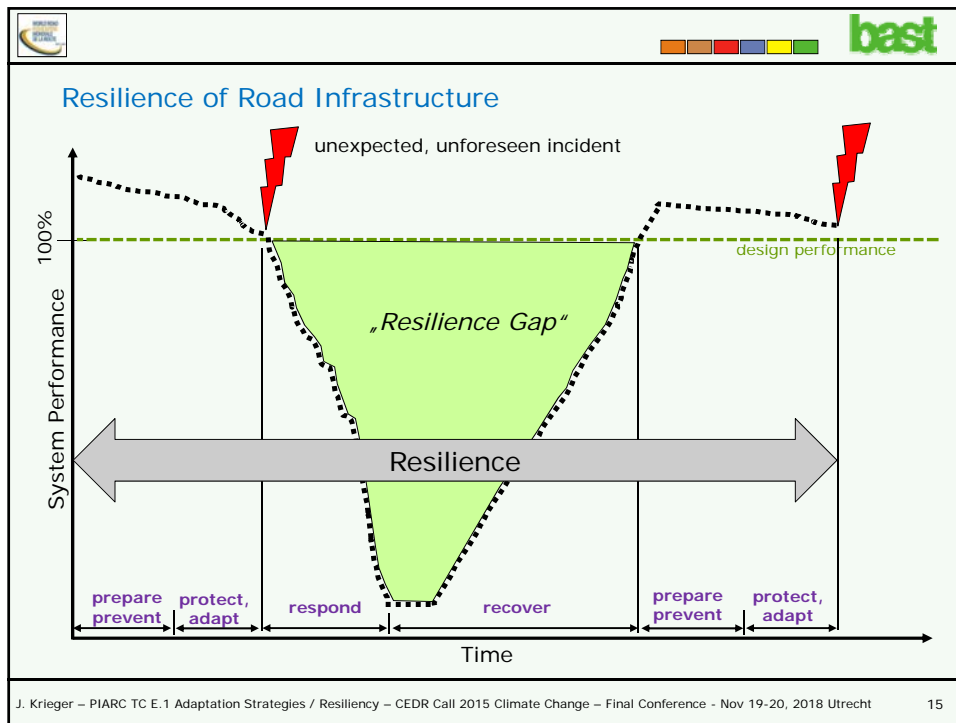
Those events are either catastrophes or processes of change with catastrophic outcome which can have human, technical or natural causes.

* Scharte, Benjamin/Hiller, Daniel/Leismann, Tobias/Thoma, Klaus (2014): Introduction - Thoma, Klaus (Hrsg.): Resilient Tech. Resilience by Design: Strategy for the technology issues of the future (acatech STUDY). München: Herbert Utz Verlag, 17.

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
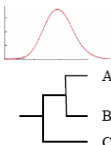

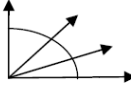
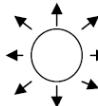
*“There are things that we know that we know;
there are things that we know that we don’t know;
there are things that we don’t know that we don’t know.”**

Levels of Uncertainty




* Donald Rumsfeld, 12 February 2002

Levels of Uncertainty

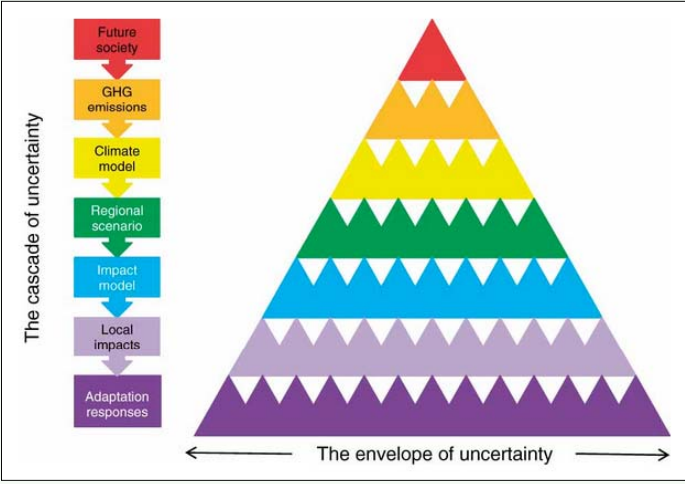
Climate Change

	Level 1	Level 2	Level 3	Level 4	Level 5
Context	<p>A clear enough future (with sensitivity)</p> 	<p>Alternate futures (with probabilities)</p> 	<p>Alternate futures (with ranking)</p> 	<p>A multiplicity of plausible futures (unranked)</p> 	<p>Unknown future</p> 
Systemmodel	A single system model	A single system model with a probabilistic parameterization	Several system models, one of which is most likely	Several system models, with different structures	Unknown system model; know we don't know

Warren E. Walker et al: Deep Uncertainty




Cascading Uncertainty – Climate Change Adaptation





← The envelope of uncertainty →


Wilby, R. , Dessai, S. (2010)

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Ingrid and Manuel Storms in Mexico



DAMAGE TO ROADS	
Total closure	17 roads and highways
Severe damage	57 roads, 15 highways and 980 rural roads
Total kilometers affected	5,000 km
Total bridges with damage	134
Collapsed bridges	9
Repair costs	\$1,200,435,414 US Dollars

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Uncertainties

Decision-making and (deep) uncertainty: *




- ❖ Robust project design despite uncertainties
- ❖ Limited usability of future forecasts (climate projections, extreme weather)

- Question: „What are the future boundary conditions that could affect the function of my system?“
- Stress Tests under consideration of all plausible and thinkable future boundary conditions
- Identification of relevant risks and specific vulnerability levels
- Analysis and assessment of options for risk reduction

*Warren E. Walker et al: Deep Uncertainty

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Adaptation Pathways

- Adaptation should entail a portfolio of response options
- Analysis of the possible extension over time of feasible options
- Adaptation paths enable decision making through:
 - ❖ Use of object-related thresholds;
 - ❖ Dealing with uncertainty in the main drivers;
 - ❖ Structuring a variety of adaptation options;
 - ❖ Identification of possible lock-ins; and
 - ❖ Inclusion of multiple stakeholder preferences

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PIARC - Strategic Plan TCE.1

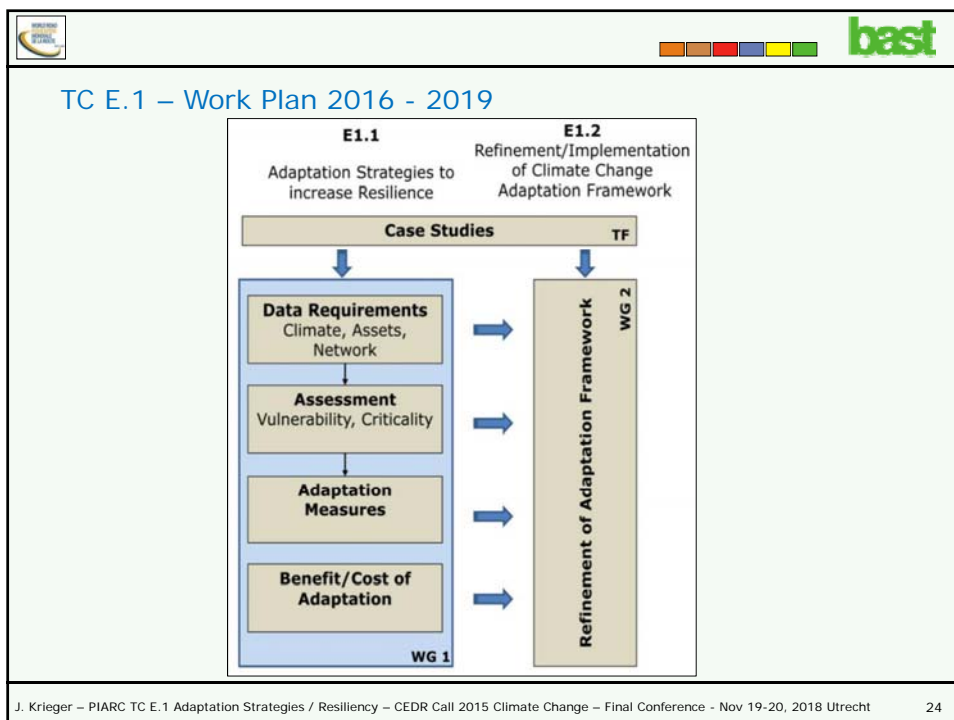
TC E.1 Adaptation Strategies/Resiliency



Issue E.1.1	
Adaptation strategies to increase resiliency	
Strategies	Outputs
To investigate and disseminate information about current adaptation strategies to increase the resiliency of road infrastructure.	Report based on case studies
Issue E.1.2	
Climate Change Adaptation Framework	
Strategies	Outputs
Refinement of the Climate Change Adaptation Framework (based on the Special Project developed in the 2011-2015 cycle) and follow-up of its implementation.	Report based on case studies



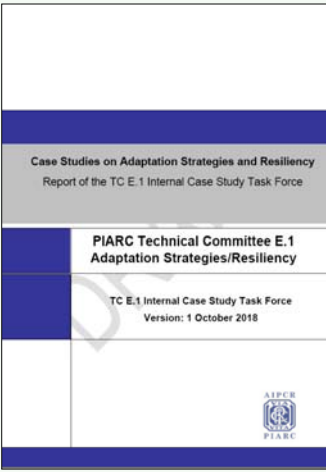
WORLD ROAD ASSOCIATION
STRATEGIC PLAN
2016-2019

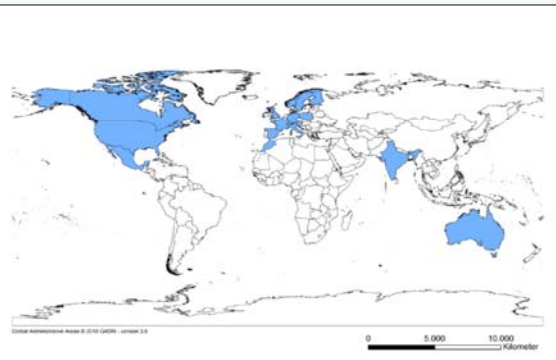
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Work Plan – Task Force Case Studies



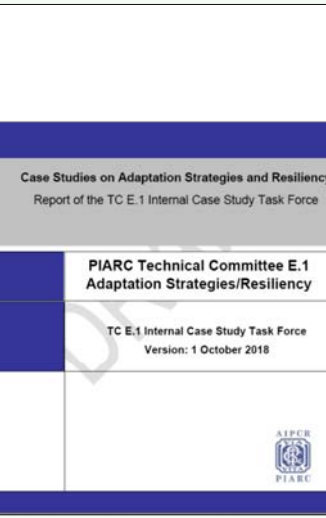


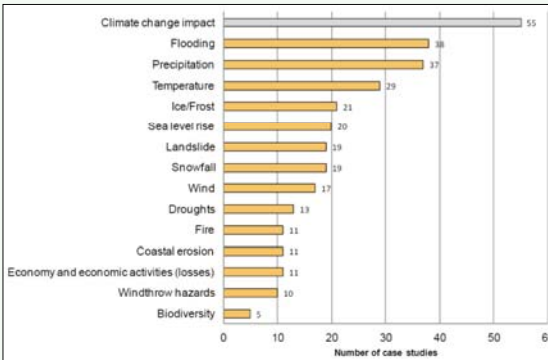
Countries (in blue) for which case studies were classified in this survey

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Work Plan – Task Force Case Studies









Category	Number of case studies
Climate change impact	55
Flooding	38
Precipitation	37
Temperature	29
Ice/Frost	21
Sea level rise	20
Landslide	19
Snowfall	19
Wind	17
Droughts	13
Fire	11
Coastal erosion	11
Economy and economic activities (losses)	11
Windthrow hazards	10
Biodiversity	5

Number of case studies classified to the category "Climate change impact" and number of case studies per subcategory of "Climate change impact".

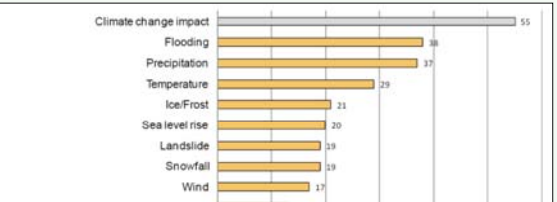
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Work Plan – Task Force Case Studies




Case Studies on Adaptation Strategies and Resiliency
Report of the TC E.1 Internal Case Study Task Force



Subcategory	Number of case studies
Climate change impact	55
Flooding	38
Precipitation	37
Temperature	29
Ice/Frost	21
Sea level rise	20
Landslide	19
Snowfall	19
Wind	17
Droughts	13

Database on TC E.1 Workspace




Version: 1 October 2018



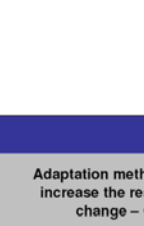
Number of case studies classified to the category "Climate change impact" and number of case studies per subcategory of "Climate change impact".

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TC E.1 – WG1 Deliverable






Adaptation methods to increase the resilience of roads to climate change




- 1 INTRODUCTION
- 2 PURPOSE OF THE REPORT
- 3 STRUCTURE OF THIS REPORT
- 4 OVERVIEW OF THE INTERNATIONAL CLIMATE CHANGE ADAPTATION FRAMEWORK FOR ROADS
 - 4.1 IMPLEMENTING THE PIARC CLIMATE CHANGE ADAPTATION FRAMEWORK FOR ROADS IN MEXICO
 - 4.2 IMPLEMENTING THE PIARC CLIMATE CHANGE ADAPTATION FRAMEWORK IN AUSTRALIA
 - 4.3 IMPLEMENTING THE PIARC FRAMEWORK IN PARAGUAY









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TC E.1 – WG1 Deliverable	
	5 OVERVIEW OF THE INFORMATION COLLECTION PROCESS
	5.1 CASE STUDY COLLECTION FROM THE TC INTERNAL TASK FORCE
	5.2 TASK FORCE METHODOLOGY
Adaptation meth increase the re change –	5.3 TASK FORCE RESULTS
	5.4 APPROACH TO IDENTIFYING CASE STUDIES FOR THIS DOCUMENT
PIARC Adaptatio	6 INFORMATION REQUIREMENTS AND CONTEXT FOR GUIDELINES APPLICATION
	6.1 DEFINITIONS
	6.2 DEFINING OBJECTIVES AND SCOPE OF A HOLISTIC RISK ASSESSMENT
	6.3 PRACTICAL ADVICE TO LEAD A HOLISTIC RISK ASSESSMENT
	6.4 GENERAL CONSIDERATION ON METHODOLOGIES TO ASSESS EXPOSURE, SENSITIVITY, CRITICALITY AND RISK
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TC E.1 – WG1 Deliverable	
	7 EXPOSURE ASSESSMENT
	7.1 DEFINITION OF CLIMATE EXPOSURE
	7.2 SELECTION OF THE CLIMATE HAZARDS
	7.3 SELECTION OF CLIMATE CHANGE SCENARIOS
	7.4 EXPOSURE SCORING
Adaptation meth increase the re change –	8 TECHNIQUES AND TOOLS REQUIRED FOR ASSESSING SENSITIVITY, VULNERABILITY AND CRITICALITY
PIARC Adaptatio	8.1 ASSESSING SENSITIVITY
	8.2 ASSESSING CRITICALITY
	9 HOW IS A RISK ASSESSMENT APPLIED?
	9.1 QUALITATIVE FRAMEWORK RANGES AND CALCULATION
	9.2 INDICATOR BASED APPROACHES
	9.3 QUANTITATIVE RISK ANALYSIS, ASSESSMENT AND PROBABILISTIC RISK ANALYSIS APPROACH
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TC E.1 – WG1 Deliverable	
	10 SELECTING AND MONITORING ADAPTATION MEASURES AND RESPONSES
	10.1 IDENTIFYING TYPES OF ADAPTATION MEASURES
	10.2 EVALUATION OF THE EFFECTIVENESS/MONITORING OF ADAPTATION MEASURES
Adaptation meth increase the re change –	11 APPROACHES TO INCLUDING ADAPTATION IN APPRAISAL & EVALUATION
	11.1 ECONOMIC METHODOLOGIES
	11.2 PRIORITISATION OF RESILIENCE OPTIONS ANALYSIS
PIARC Adaptatic	11.3 DEVELOPING AN ADAPTATION ACTION PLAN AND VERIFYING THE COST EFFECTIVENESS OF MEASURES EX-POST, BENEFIT REALISATION
	12 IDENTIFICATION OF EXISTING GAPS
	12.1 GAPS BASED ON THE REPORT FINDINGS
	13 CONCLUSIONS
	14 Bibliography / References
	15 Glossary
	16 Appendices
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TC E.1 – WG2 Deliverable	
	1 INTRODUCTION
	2 PURPOSE OF THE REPORT
Ref Clima	3 STRUCTURE OF THE REPORT
A	4 OVERVIEW OF PIARC'S "INTERNATIONAL CLIMATE CHANGE ADAPTATION FRAMEWORK FOR ROAD INFRASTRUCTURE"
	5 REFINEMENT OF THE PIARC FRAMEWORK – TASKS AND AIMS
	6 EXAMPLES OF IMPLEMENTATION OF THE PIARC FRAMEWORK
	6.1 IMPLEMENTING THE PIARC FRAMEWORK IN MEXICO
	6.2 IMPLEMENTING THE PIARC FRAMEWORK IN QUEENSLAND
	6.3 IMPLEMENTING THE PIARC FRAMEWORK IN PARAGUAY
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TC E.1 – WG2 Deliverable

Ref
Clim

- 7 INPUT FROM CASE STUDIES AND BENCHMARKING
 - 7.1 COLLECTED EXAMPLES FROM CASE STUDIES (TC E.1 TASK FORCE)
 - 7.2 THE BENCHMARKING EXERCISE
 - 7.3 COMPARISON OF FRAMEWORKS IN THE QUEENSLAND PROJECT
 - 7.4 OTHER INPUT FROM CASE STUDIES (WG1)
- 8 COMMENTS ON THE FRAMEWORK FROM COUNTRY MEMBERS
 - 8.1 COUNTRY COMPARISONS
 - 8.2 AUSTRALIA /QUEENSLAND - OVERLAYING THE PIARC FRAMEWORK OVER ONGOING ADAPTATION WORK

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TC E.1 – WG2 Deliverable

Ref
Clim

- 9 FINDINGS FROM WORKSHOPS
- 10 POSSIBILITIES FOR REFINEMENT OF THE FRAMEWORK
 - 10.1 APPLICABILITY OF THE FRAMEWORK
 - 10.1.1 PERFORMING A GENERAL ASSESSMENTS OF RISKS
 - 10.1.2 ADDRESSING THE PLANNING PHASE OF A ROAD CONSTRUCTION PROJECT
 - 10.2 COMBINING THE COMPONENTS OF RISK
 - 10.3 INTRODUCING THE ASPECT OF CRITICALITY
 - 10.4 USING THE SCORE OF ADAPTIVE CAPACITY

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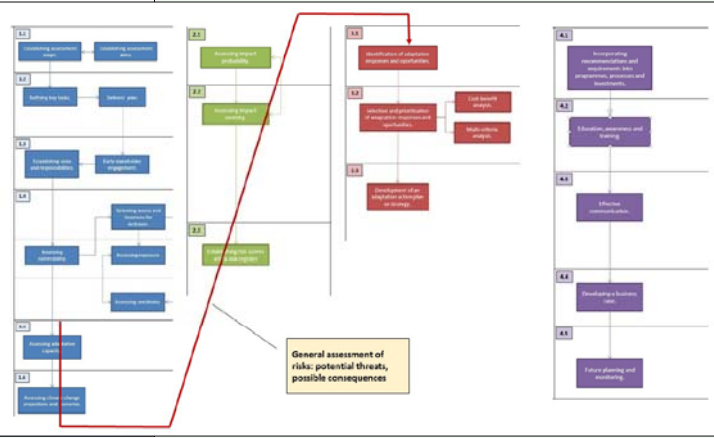




TC E.1 – WG2 Deliverable

Refinement of PIARC Climate Change Adaptation Framework for Road Infrastructure

PIARC Technical Adaptation Strategy




Work Version: _____



Schematic presentation of the use of the Framework for a general assessment of risks

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TC E.1 Adaptation Strategies / Resiliency – next steps?

Fundamental update of the PIARC Climate Change Adaptation Framework

Points to be addressed:

- Strict separation of processes and methodologies
- Division of the framework into two separate parts:
 - Part 1 should contain only processes and their description
 - Part 2 should include possible methodologies, their data requirements and application limits
- The work will be based on the more than 100 case studies already available by the end of this cycle.
- Collection and analysis of further case studies.
- Consideration of new and innovative methodological approaches and standards

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Thank You very much for your kind attention!

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