



La resilienza delle infrastrutture stradali



Ordine degli Ingegneri della Provincia di Roma

La progettazione ambientale come risposta ai cambiamenti climatici

11 ottobre 2019

Ing. Marco Garozzo



Échanger connaissances et techniques sur les routes et le transport routier / *Exchange knowledge and techniques on roads and road transportation*

AGENDA

AIPCR & Climate Change

AIPCR Overview

AIPCR Research Program

AIPCR Research Framework 2020-2023

Resilient Infrastructures

GHG and Climate Scenario

Terminology

CC Impacts on Road Infrastructure

Main Actors & Responsibilities in the CC Challenge

The ENVISION Protocol



The World Road Association

*The World Road Association-PIARC was **established in 1909**. It brings together the road administrations of **122 governments** and has members - individuals, companies, authorities and organizations - in over **140 countries**.*

The motto of AIPCR is:

EXCHANGE
Knowledge and techniques on roads and road transportation

Non-political, non-profit Association with consultative status to the United Nations

KNOWLEDGE ACQUISITION AND SHARING COMMUNICATION AND
DISSEMINATION KNOW-HOW – www.piarc.org

How AIPCR Works

17 TECHNICAL COMMITTEES, 6 TASK FORCES

- More than 1000 experts and decision-makers from the member countries of the Association.
- Identify best practice and the role of the international transportation system; share experiences and knowledge through 5 strategic themes.
- Work program reviewed and redefined every 4 years.

ST A MANAGEMENT AND PERFORMANCE

- TC A.1 Performance of Transport Administrations
- TC A.2 Road Transport System Economics and Social Development
- TC A.3 Risk Management
- TF A.1 Innovative Financing
- TF A.2 Coordination between National and Sub-National authorities

ST B ACCESS AND MOBILITY

- TC B.1 Road Network Operations/Intelligent Transportation Systems
- TC B.2 Winter Service
- TC B.3 Sustainable Multimodality in Urban Areas
- TC B.4 Freight
- TF B.1 Road Design and Infrastructure for Innovative Transport Solutions

ST C SAFETY

- TC C.1 National Road Safety Policies and Programmes
- TC C.2 Design and Operations of Safer Road Infrastructure
- TF C.1 Infrastructure Security

ST D INFRASTRUCTURE

- TC D.1 Assets Management
- TC D.2 Pavements
- TC D.3 Bridges
- TC D.4 Rural Roads and Earthworks
- TC D.5 Road Tunnels Operations

TS E CLIMATE CHANGE, ENVIRONMENT AND DISASTERS

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

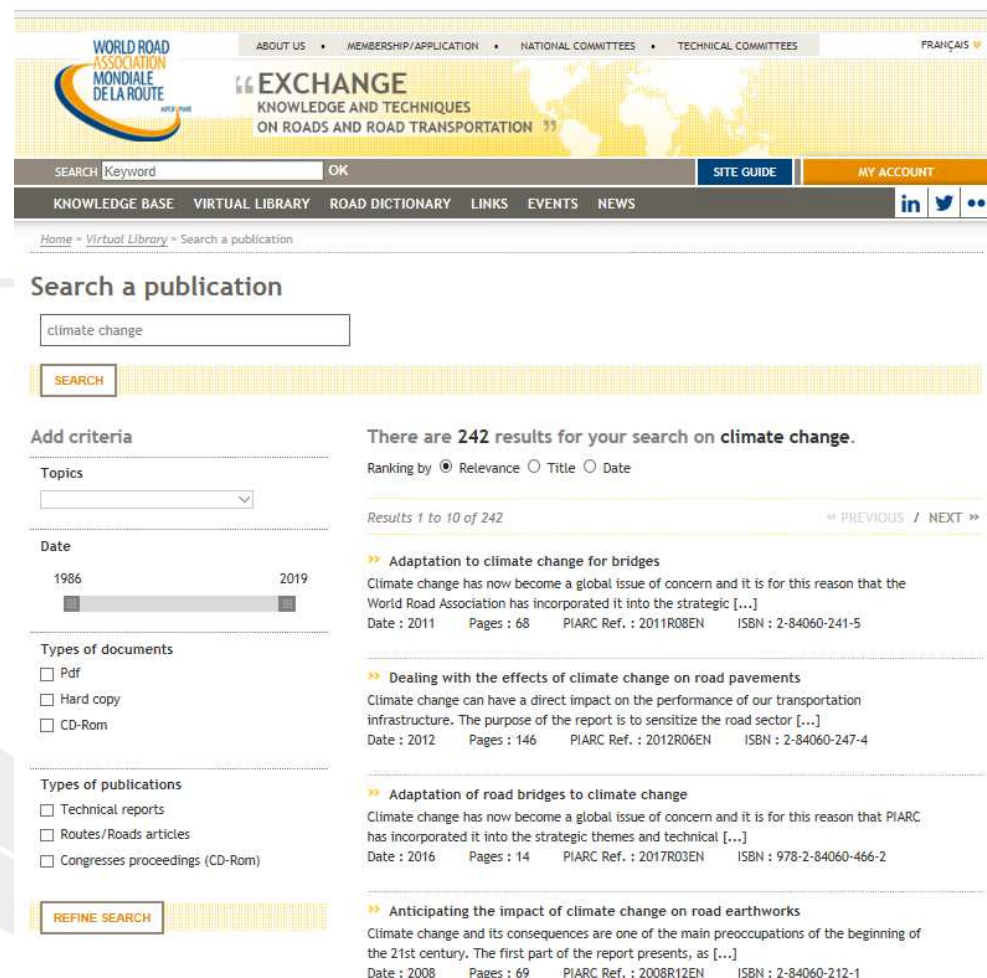
REGIONAL TASK GROUPS

Geometric and Structural Design Standards for African Highway Network
Updating of Guidelines for Rural Roads

TERMINOLOGY

Influence of climatic changes on infrastructures design, construction and management

The AIPCR Library



WORLD ROAD ASSOCIATION MONDIALE DE LA ROUTE AIPCR PIARC

ABOUT US • MEMBERSHIP/APPLICATION • NATIONAL COMMITTEES • TECHNICAL COMMITTEES FRANÇAIS

EXCHANGE KNOWLEDGE AND TECHNIQUES ON ROADS AND ROAD TRANSPORTATION

SEARCH Keyword OK SITE GUIDE MY ACCOUNT

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climate change

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☐ Pdf

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☐ CD-Rom

Types of publications

☐ Technical reports

☐ Routes/Roads articles

☐ Congresses proceedings (CD-Rom)

REFINE SEARCH

There are **242** results for your search on **climate change**.

Ranking by ☒ Relevance ☐ Title ☐ Date

Results 1 to 10 of 242

» PREVIOUS / NEXT »

» Adaptation to climate change for bridges

Climate change has now become a global issue of concern and it is for this reason that the World Road Association has incorporated it into the strategic [...]

Date : 2011 Pages : 68 PIARC Ref. : 2011R08EN ISBN : 2-84060-241-5

» Dealing with the effects of climate change on road pavements

Climate change can have a direct impact on the performance of our transportation infrastructure. The purpose of the report is to sensitize the road sector [...]

Date : 2012 Pages : 146 PIARC Ref. : 2012R06EN ISBN : 2-84060-247-4

» Adaptation of road bridges to climate change

Climate change has now become a global issue of concern and it is for this reason that PIARC has incorporated it into the strategic themes and technical [...]

Date : 2016 Pages : 14 PIARC Ref. : 2017R03EN ISBN : 978-2-84060-466-2

» Anticipating the impact of climate change on road earthworks

Climate change and its consequences are one of the main preoccupations of the beginning of the 21st century. The first part of the report presents, as [...]

Date : 2008 Pages : 69 PIARC Ref. : 2008R12EN ISBN : 2-84060-212-1

AIPCR and Climate Change

Cycle 2008- 2011

Strategic Theme A: **Sustainability of the Road Transport System**

T.C. A.1: **Preserving The Environment**

Cycle 2012- 2015

Strategic Theme 1: **Management and Performance**

T.C. 1.3: **Climate Change and Sustainability**

Cycle 2016- 2019

Strategic Theme E: **Climate Change, Environment and Disasters**

T.C. E.1: **Climate Change Adaptation Strategies/Resiliency**

Cycle 2020- 2023

Strategic Theme 1: **Road Administration**

T.C. 1.4: **Climate Change and Resilience of Road Network**

Strategic Theme 4: **Resilient Infrastructure**

T.C. : Pavements (4.1), Bridges (4.2), Earthworks (4.3), Tunnels (4.4)

ENVIRONMENT AND ROADS



ENVIRONMENTAL
SUSTAINABILITY & CC



CLIMATE CHANGE
MITIGATION

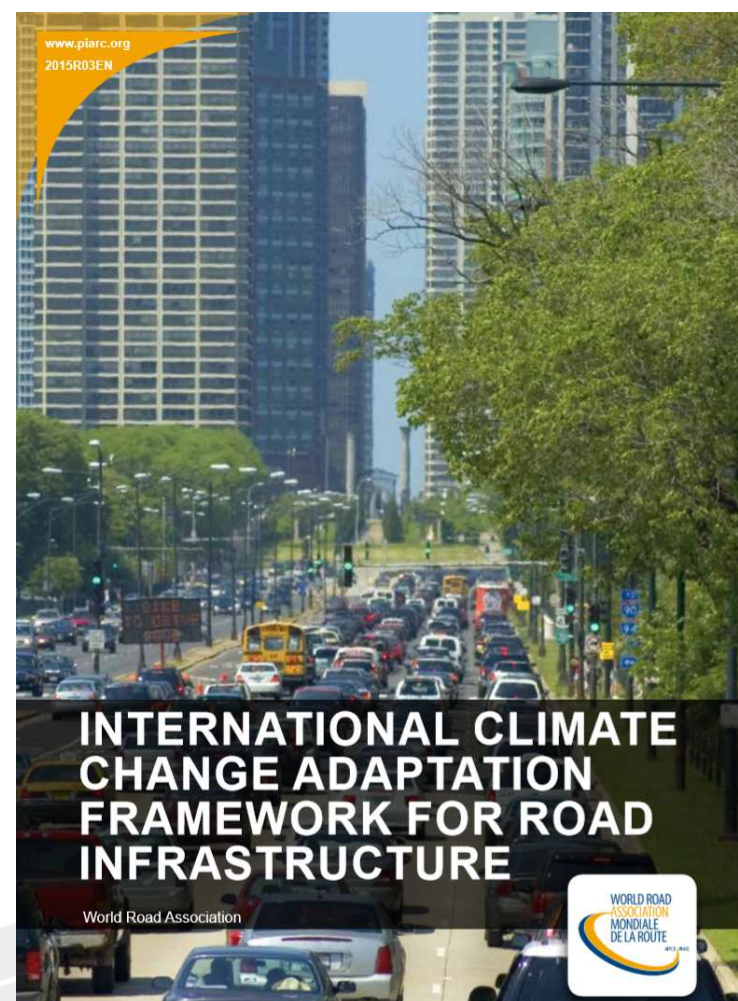
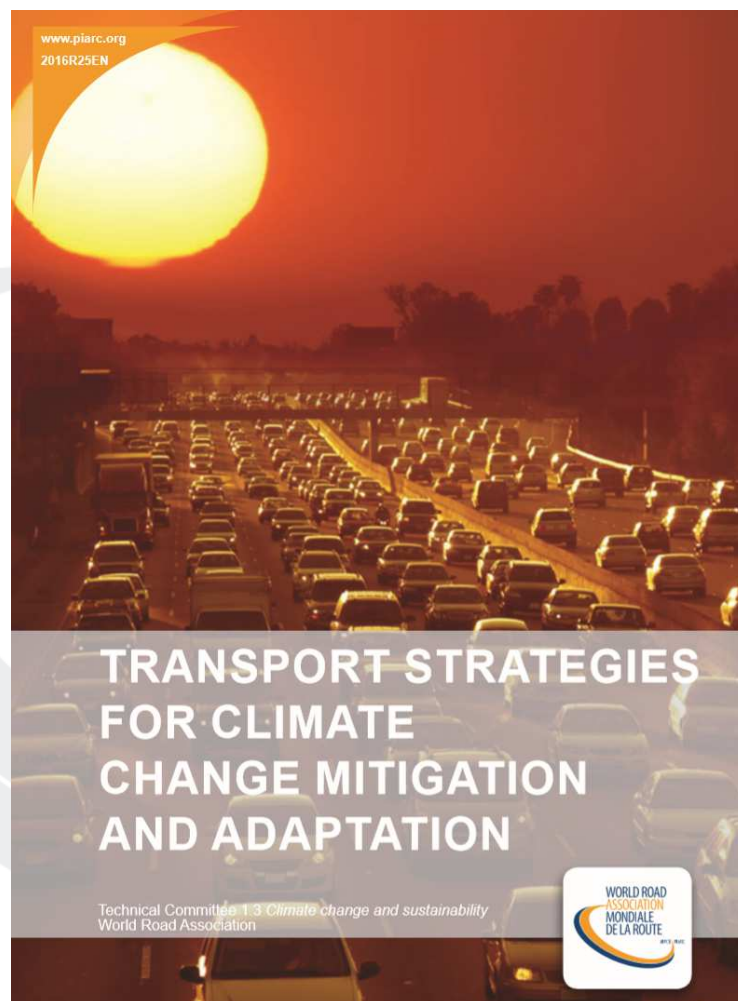


CLIMATE CHANGE
ADAPTATION/RESILIENCE



ROAD NETWORK
RESILIENCE
& ASSET RESILIENCE

The AIPCR Strategic Plan 2012-2015 Climate Change and Sustainability



The AIPCR Strategic Plan 2020-2023

Adaptation Strategy and Resilience

Uniform and holistic methodological approaches to Climate Change and other hazards resilience	
Strategies / Objectives	Outputs
<ul style="list-style-type: none"> Identification of hazards and environmental threats within the context of road infrastructure resilience. Approaches to: <ul style="list-style-type: none"> Risk management within the context of resilience Decision-making and uncertainties/deep uncertainties Emergency management with the context of resilience Resilience management and resilience engineering Define criteria to implementation of resilience into asset management practice. Take into account works carried out by T.C.E.1 – Adaptation Strategies/Resiliency within Cycle 2016-2019, in particular the re-evaluation of 100 already case studies to identify those with this holistic methodology. Coordinate with T.C.1.5 – Disaster Management, T.C.3.2 – Road Network Operation, T.C.3.3 – Winter Service, T.C.3.4 – Asset Management, T.F.3.2 – Road Infrastructure and Transport Security, T.C.4.1 – Pavements, T.C.4.2 – Bridges, T.C.4.3 – Earthworks, T.C.4.4 – Tunnels and T.F.4.1 – Road Design Standards. 	<ul style="list-style-type: none"> Survey/questionnaire on the topics of holistic resilience approach, resilience measures and financial aspects of resilience management. Collection of case studies. Roundtable / Workshop with participation of all relevant TCs & TFs. Briefing note. Conference Session called “Winter resilience”, for International Winter Road Congress in Calgary. Other possible Conference Sessions (TRB Annual meeting, IABSE, IABMAS,...). Seminar in LMIC. Full report based on case studies.

Financial aspects of resilience management	
Strategies / Objectives	Outputs
<ul style="list-style-type: none"> Identification of the socio-economic impacts of hazards on roads. Identification of decision areas that need enhanced economic information, and on the key users of such information. Search for economic methodologies for increasing the resilience of road infrastructure (catalogue of measures including their technical effectiveness), including cost-benefit analysis, multi-criteria analysis and adaptation pathways. Economic evaluation of resilience measures and post-completion evaluation. Impact and economic evaluation of measures to increase resilience on the availability of road transport infrastructure, and the cost-effectiveness of different adaptation strategies. Coordinate with T.C.1.3 – Finance and Procurement, T.C.1.5 – Disaster Management, T.C.3.2 – Road Network Operation, T.C.3.3 – Winter Service, T.C.3.4 – Asset Management, T.F.3.2 – Road Infrastructure and Transport Security, T.C.4.1 – Pavements, T.C.4.2 – Bridges, T.C.4.3 – Earthworks, T.C.4.4 – Tunnels and T.F.4.1 – Road Design Standards. 	<ul style="list-style-type: none"> Collection of case studies. Roundtable / Workshop with participation of all relevant TCs & TFs. Briefing note. Full report based on case studies.

Update of the PIARC Climate Change Adaptation Framework	
Strategies / Objectives	Outputs
<ul style="list-style-type: none"> Update of the PIARC Climate Change Adaptation Framework based in the work carried out on the other ToR of this TC: <ul style="list-style-type: none"> Setting a strict separation of processes and methodologies. Split the framework into two separate parts: <ul style="list-style-type: none"> Part 1: processes and their descriptions. Part 2: overview of possible methodologies for risk assessment and risk management, their data requirements and application limits. With integration of best-practice case studies. Consideration of new and innovative methodological approaches, in particular critically assessment, adaptation pathways and evaluation of the overall economic value of adaptation measures. 	<ul style="list-style-type: none"> International Seminar. Preferably in a country that has already implemented the PIARC Framework or similar frameworks. Conference Session for International Winter Road Congress in Calgary. Other possible Conference Sessions (TRB Annual meeting, IABSE, IABMAS,...). Full report outlining the updated Climate Change Adaptation Framework for Roads.

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The transportation contribution to CC

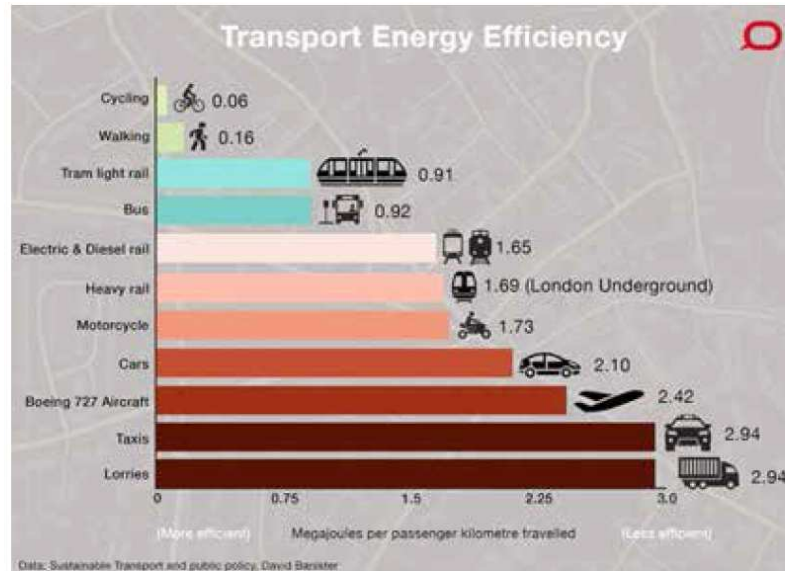


FIGURE 3 – TRANSPORT ENERGY EFFICIENCY MJ/PASSENGER KILOMETRES TRAVELLED
[SOURCE: [HTTP://THECONVERSATION.COM/WHICH-TRANSPORT-IS-THE-FAIREST-OF-THEM-ALL-24806](http://theconversation.com/which-transport-is-the-fairest-of-them-all-24806)]

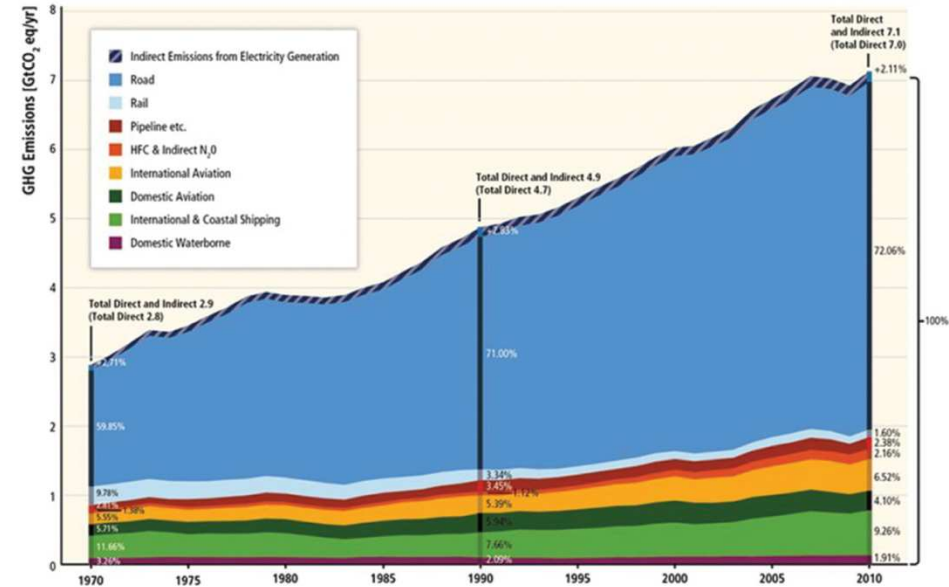


Illustration 1. Greenhouse Gas Emissions from the Transport Sector
(Source: IPCC AR5 Chapter 8)

GHG Concentration: 300 ppm 1900 – 400 ppm today – 1°C more

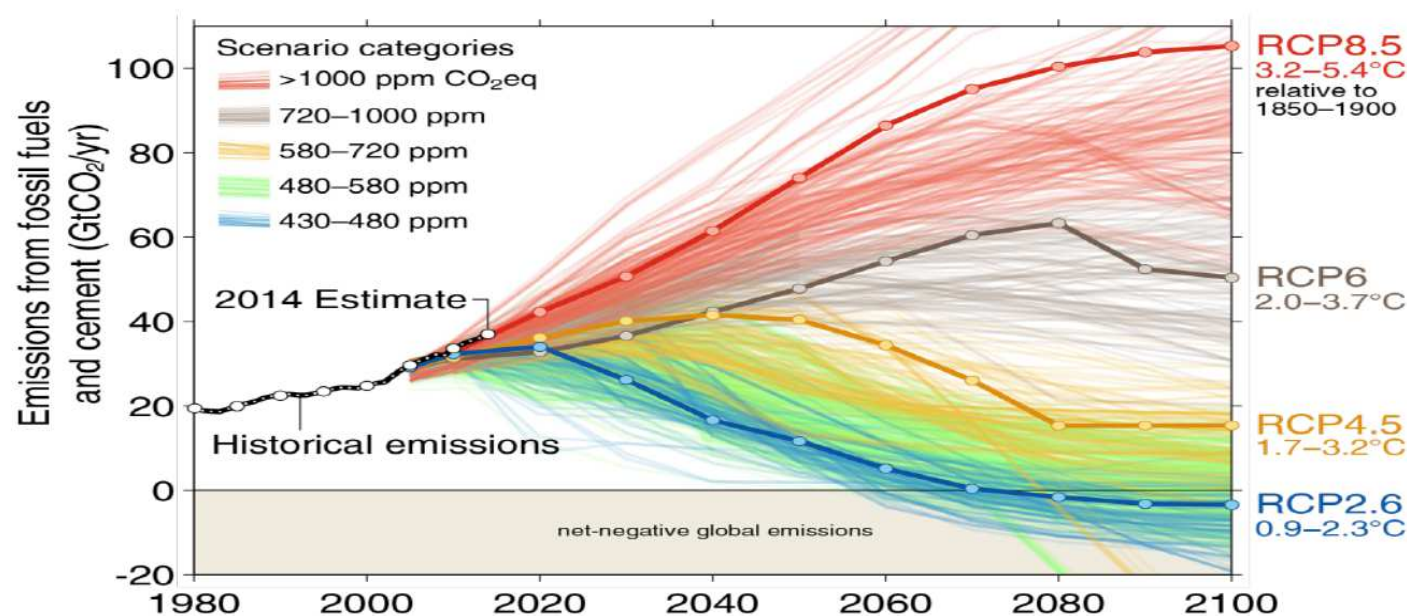
GHG Maximum to avoid irreversible CC: 450 ppm – 2°C

Nedeed reduction: 40-70% below 2010 level of emission by 2050 (1970-2010 emission level growth is 80%)

Despite mitigation policies the increasing trend between 2000 and 2010 is 2.2% (av.1970-2010 1.3%)

Transportation sector (direct emission) is 14% of total GHG but increasing rapidly with respect to the other industrial and human activity – more then doble with respect to 1970 - road transp GHG are more then triple.

The climate scenario



- RCP 2.6 – scenario di mitigazione - riduzione emissioni molto elevate
- RCP 4.5 – scenario di stabilizzazione - riduzione emissioni consistenti
- RCP 6 – scenario di stabilizzazione - riduzione emissioni blande
- RCP 8.5 – scenario a alte emissioni - «business as usual»

I numeri degli scenari RCP (Representative Concentration Pathway -indicano il forzante radiativo totale previsto al 2100 rispetto al 1750

TERMINOLOGY (1)

Climate Change (IPCC)

Climate change refers to any change in climate over time, whether **due to natural variability or as a result of human activity**.

Climate Change (UN/UNFCCC)

A change of climate which is attributed **directly or indirectly to human activity** that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

TERMINOLOGY (2)

Resilience (IPCC)

The ability of a social or ecological system to absorb disturbances while **retaining the same basic structure and ways of functioning** and the capacity to adapt to stress and change.

Resilience (ISO 28002:2011)

Resilience is the ability of an organisation to prevent or resist being affected by an event or the **ability to return to an acceptable level of performance** in an acceptable period of time being affected by an event.

TERMINOLOGY (3)

Resilience (BS 65000)

Organizational resilience is the ability of an organization to **anticipate, prepare for, and respond and adapt** to incremental change and sudden disruptions in order to survive and prosper.

Resilience (U.S.)

The ability to **prepare and plan** for, absorb, recover from, or more successfully adapt to actual or potential adverse events.

TERMINOLOGY (4)

Resilience (EU-project Resiliens)

Resilience is the ability of a system or systems **to survive and thrive** in the face of a complex, uncertain and ever-changing future. It is a way of thinking about **both short term cycles and long term trends**: minimizing disruptions in the face of shocks and stresses, recovering rapidly when they do occur, and adapting steadily to become better able to thrive as conditions continue to change.

TERMINOLOGY (5)

Adaptation (IPCC)

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

Anticipatory adaptation – Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.

Autonomous adaptation – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.

Planned adaptation – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

TERMINOLOGY (6)

Adaptation Assessment (IPCC)

The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility.

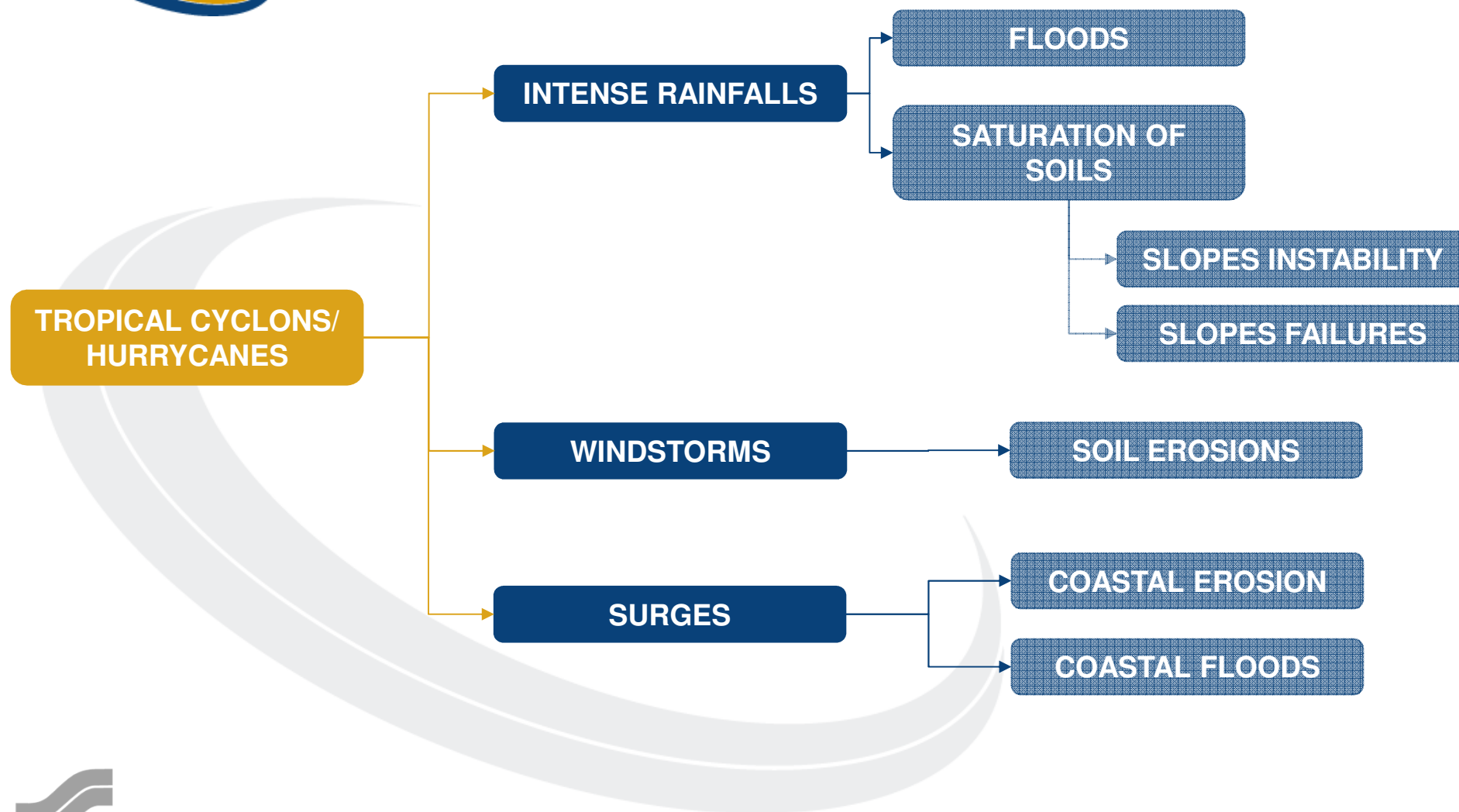
Adaptation benefits (IPCC)

The avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures.

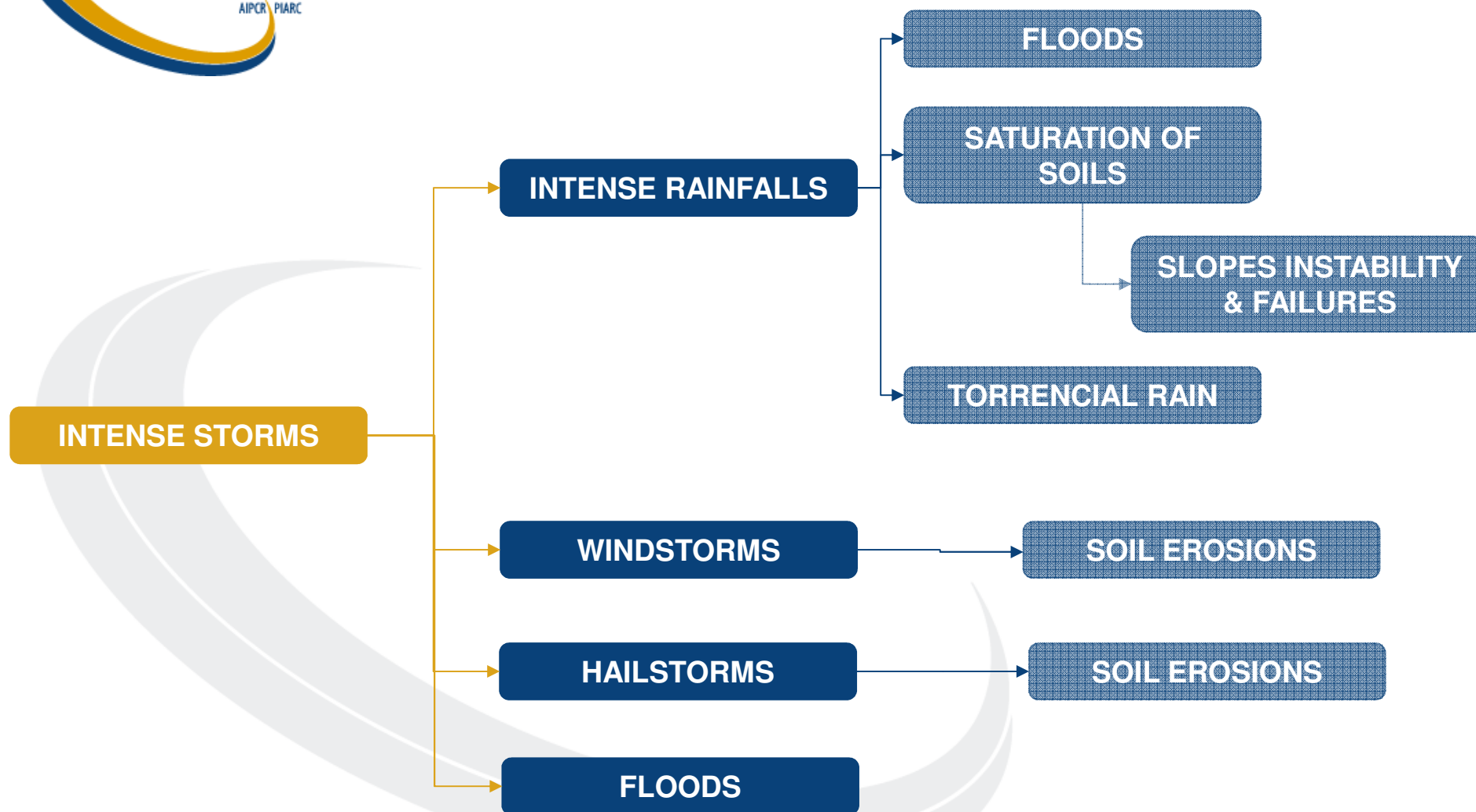
Adaptation costs (IPCC)

Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs.

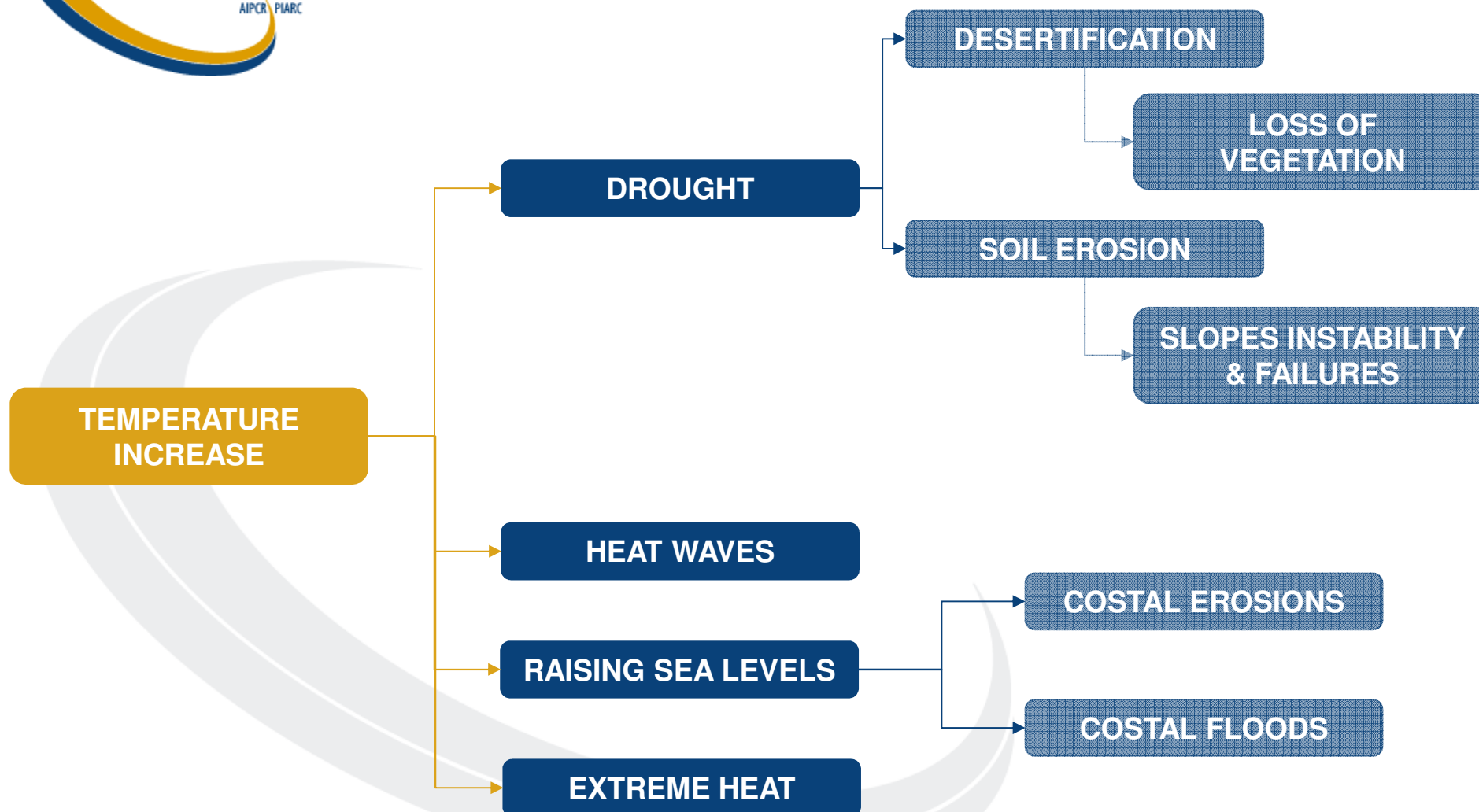
Impacts on road infrastructure associated with climate change (1)



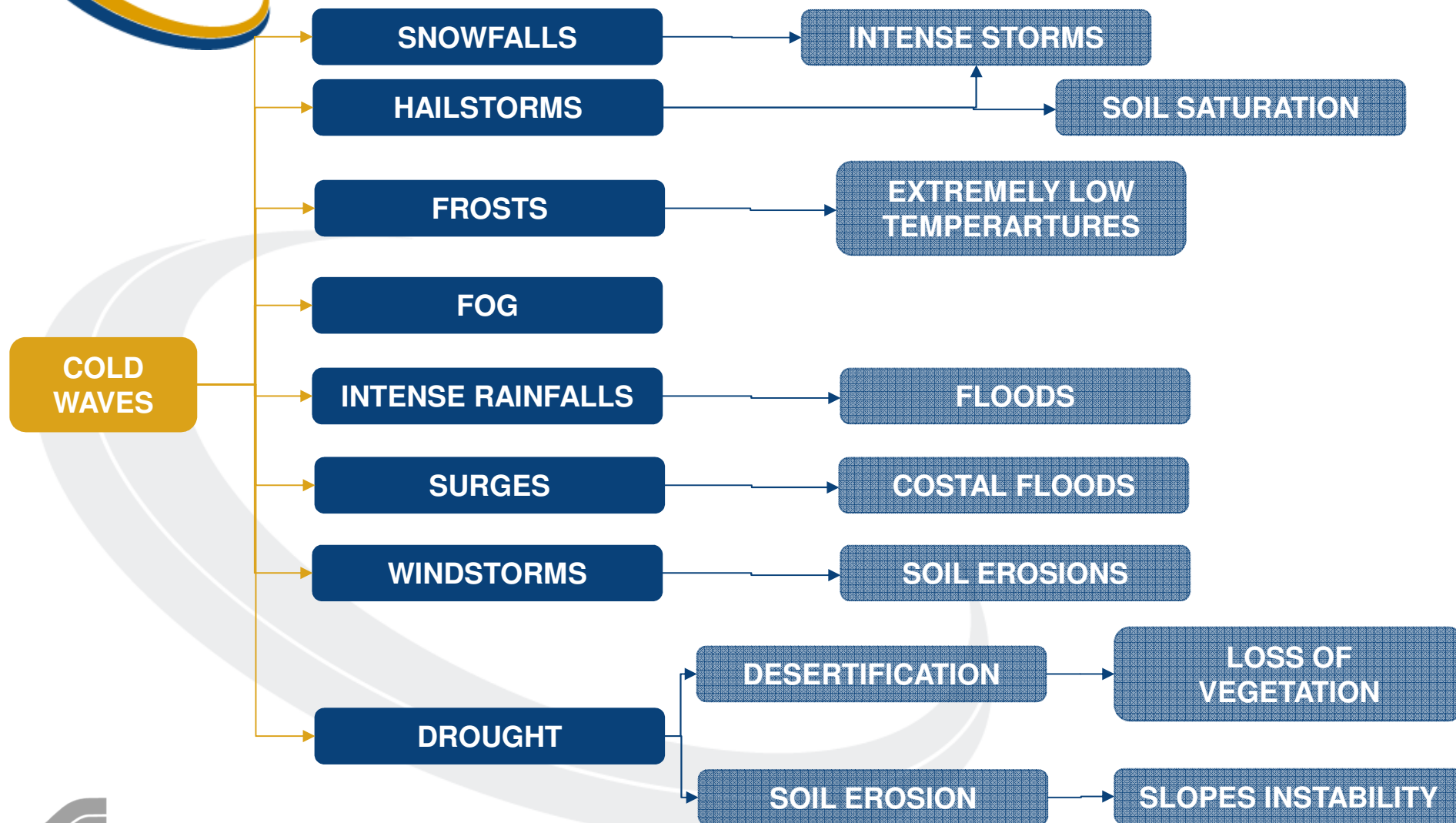
Impacts on road infrastructure associated with climate change (2)



Impacts on road infrastructure associated with climate change (3)



Impacts on road infrastructure associated with climate change (4)



Influence of climatic changes on infrastructures design, construction and management

Impacts on road infrastructure associated with climate change (5)

HIGH TEMPERATURES AND HEAT WAVES

- ☐ Damage and deformations in asphalt pavements.
- ☐ Asphalt degradation.
- ☐ Thermal expansion in concrete pavement joints and bridges.
- ☐ Limitation of working hours.
- ☐ Damage to vehicles (overheating and wear).
- ☐ Promotes forest fires (visibility/road safety).
- ☐ Affectation to the circuits of the signalling systems.



Deformation of urban pavement in India
Source: <http://i.ngenespanol.com/>



Pavement deformation (asphalt exudate)
Source: <http://hechosdetransito.com>

Impacts on road infrastructure associated with climate change (6)

TROPICAL CYCLONES, HURRICANES AND STORM SURGES

- ❑ Damage to road signs.
- ❑ Obstructions due to falling trees and road signs.
- ❑ Landslides on cuts, embankments or slopes.
- ❑ Flooding of the running surface.
- ❑ Modification of the coastline affecting coastal roads.
- ❑ Undermining of pavement layers on coastal roads.
- ❑ Insufficient drainage.
- ❑ Loss of infrastructure (bridges, etc.).



Hurricane landslides in Mexico
Source Reforma Newspaper, 2013



Loss of bridge, Highway XXI century, Mexico
Source: periodismoaudaz.com.mx

Impacts on road infrastructure associated with climate change (7)

INCREASED STORMS AND PRECIPITATION

- ❑ Traffic interruption due to weather.
- ❑ Inadequate device visibility.
- ❑ Flooding of the bearing surface.
- ❑ Slides and landslides of material on slopes and slopes. Insufficient drainage works (damages and losses).
- ❑ Structural instability (bridges and culverts).
- ❑ Undermining of pavement layers.
- ❑ Interruption of maintenance work.



Flooding of the bearing surface
Source: pueblanoticias.com.mx



Slope slides in Mexico
Source Unidentified

Impacts on road infrastructure associated with climate change (8)

HIGH PRESENCE OF WATER AND FLOODS

- ☐ Changes in surface runoff patterns.
- ☐ Greater presence of water on the running surface.
- ☐ Instability of structures.
- ☐ Damage to the pavement and its layers.
- ☐ Increased rate of socavation.
- ☐ Increased design hydraulic expense for bridges and culverts.
- ☐ Soil erosion and accumulation of debris in the wearing course.
- ☐ Increased soil moisture.



Loss of sewer on the 21st century motorway
Source: periodismoaudaz.com.mx



Drainage on cutting slopes
Source: desinformemonos.org.mx 25

Impacts on road infrastructure associated with climate change (9)

GALES OR STRONG WINDS

- ❑ Falling trees, power poles, and advertisements.
- ❑ Instability of vehicles on roads and bridges.
- ❑ Increased erosion of slopes and embankments.
- ❑ Loss of vertical signage on roads.
- ❑ Damage to the electrical supply or transmission.
- ❑ Structural damage to bridges.



Fallen road markings
Source: ntrguadalajara.com



Trees fallen on the road
Source: domain.fm

Impacts on road infrastructure associated with climate change (10)

DROUGHT AND FIRES

- ☐ Lack of water for the construction process.
- ☐ Increased soil erosion.
- ☐ Loss of vegetation cover in the right-of-way and in the basins.
- ☐ Increased likelihood of forest fires.
- ☐ Increased surface runoff.
- ☐ Degradation of foundation layers.
- ☐ Dust generation.



Roadside fire
Source: contextoganadero.com



Trees fallen on the road
Source IC Ingeniería Civil" Magazine No. 508

Impacts on road infrastructure associated with climate change (11)

LOW TEMPERATURES AND COLD WAVES

- ❑ Damage to the pavement (freeze-thaw cycles).
- ❑ Winter floods.
- ❑ Increased runoff due to snowfall or hailstorms.
- ❑ Partial road closures due to the accumulation of ice on the bearing surface.
- ❑ Low temperatures can affect the electrical circuits of signaling systems.
- ❑ Negative effects on road safety.



Nevada in Mexico
Source Millennium.com



Granizada/Nevada in Mexico
Source: elsiglodetorreon.com.mx

Main Actors and Responsibilities in the CC Challenge (1)

	Mitigation	Adaptation & Resilient
Public Road Authorities	<ul style="list-style-type: none"> • Planning new sustainable mobility • Mode choice options • Public Transport • Fiscal & tax 	<ul style="list-style-type: none"> • Planning mobility network • Rules, standard & guideline
Designers	<ul style="list-style-type: none"> • Carbon footprint for new project • Design standard & best practice 	<ul style="list-style-type: none"> • New Materials • Risk Analysis • New Assessment tools

Main Actors and Responsibilities in the CC Challenge (2)

	Mitigation	Adaptation & Resilient
Construction Companies	<ul style="list-style-type: none"> • Use of new technologies • Use of new and recycle materials 	Not directly involved
Operators	<ul style="list-style-type: none"> • Traffic Management • Facilities for green mobilities 	<ul style="list-style-type: none"> • Risk Analysis and preventive maintenance • Adaptive maintenance • Traffic Management
Road Users & End Users	<ul style="list-style-type: none"> • Virtuos behavior 	Not directly involved

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Sustainability Infrastructure Rating System

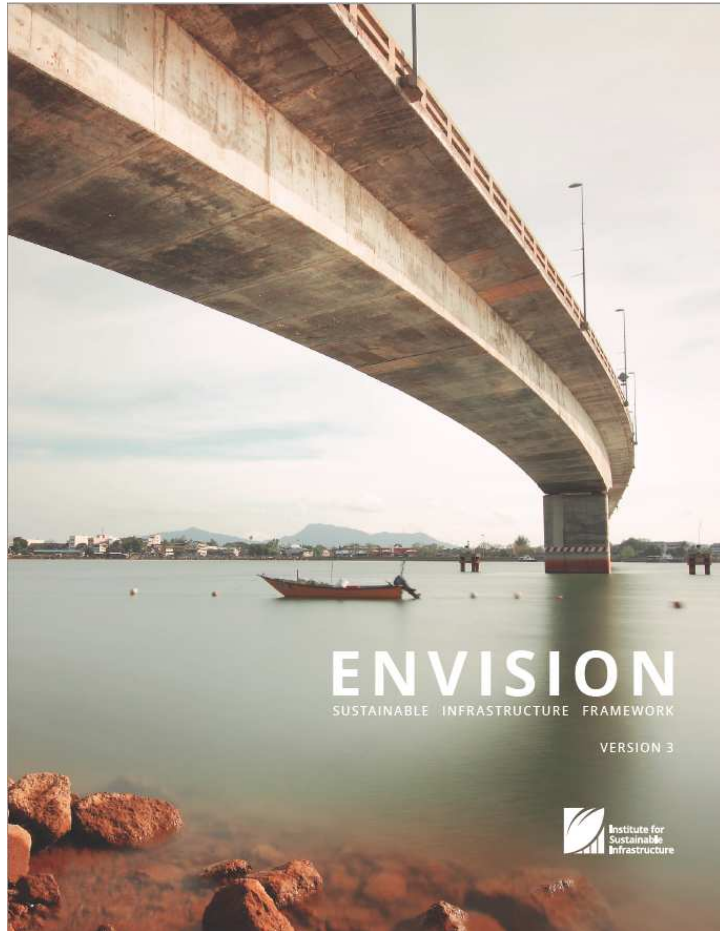
Envision is an objective framework of criteria designed to help identify ways in which sustainable approaches can be used to plan, design, construct and operate infrastructure projects. Envision not only asks, **Are we doing the project right?** but also, **Are we doing the right project?**

The use of Envision can benefit projects in numerous ways including:

- Long-term viability through increased resiliency and preparedness
- Lower costs through management and stakeholder collaboration
- Reduced negative impacts on the community and the environment
- Potential to save owners money over time through efficiency
- Credibility of a third-party rating system
- Increased public confidence and involvement in decision making

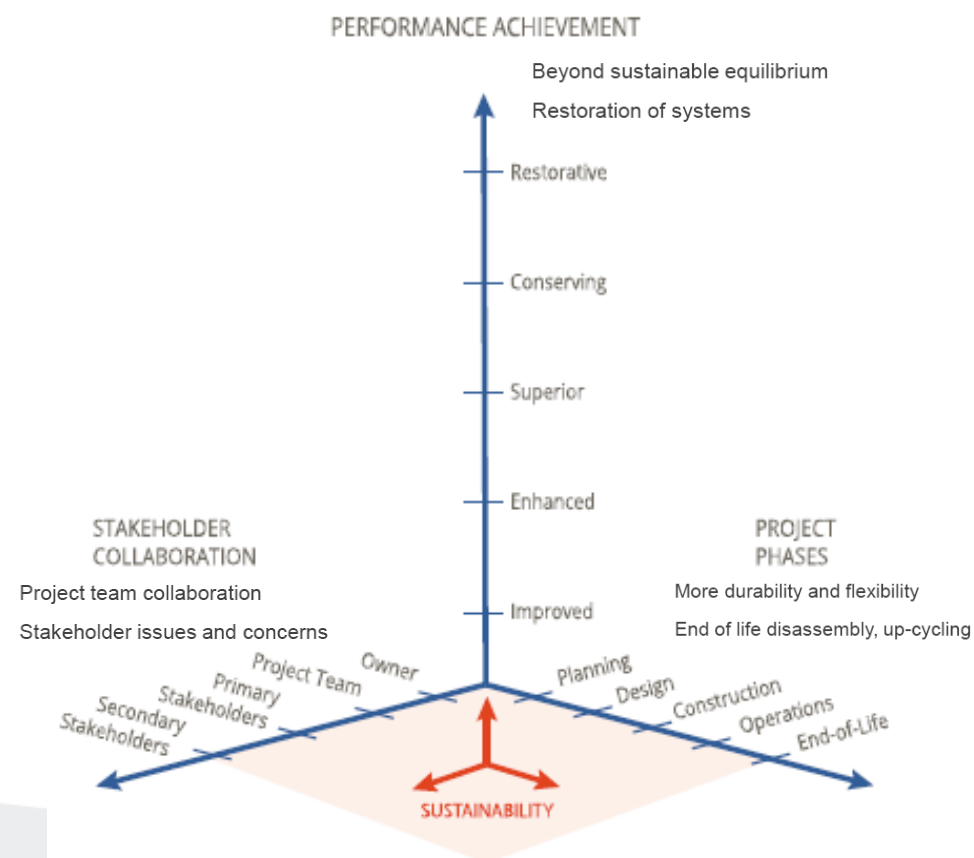
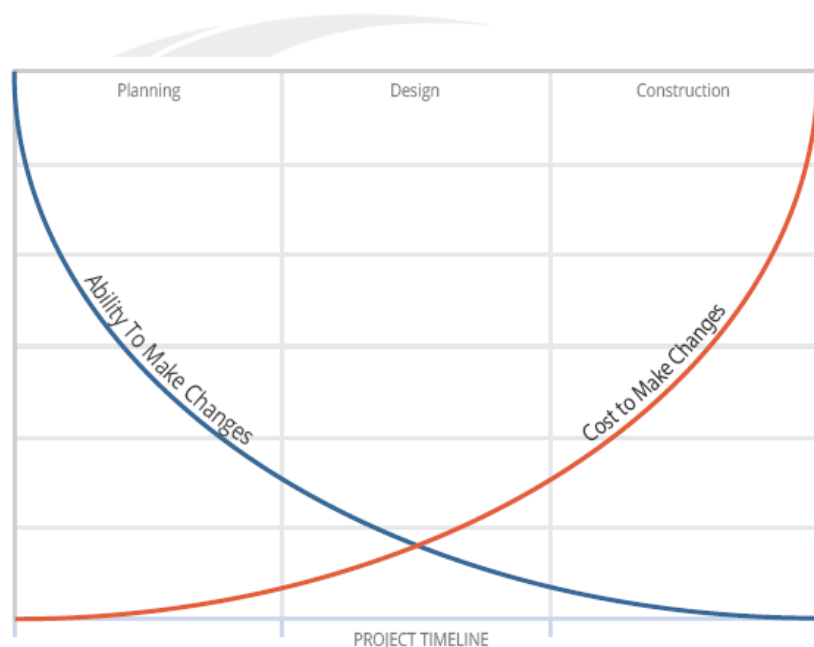
BACKGROUND

Envision was developed in joint collaboration between the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure (ISI). ISI is a not-for-profit education and research organization founded by the American Public Works Association, the American Council of Engineering Companies, and the American Society of Civil Engineers.



Making the Most of Opportunities

ENVISION not only asks, *Are we doing the project right?* but also, *Are we doing the right project?*



ENVISION Credit List



**Quality
Of Life**
14 Credits



Leadership
12 Credits



**Resource
Allocation**
14 Credits



**Natural
World**
14 Credits



**Climate and
Resilience**
10 Credits

WELLBEING

- QL1.1 Improve Community Quality of Life
- QL1.2 Enhance Public Health & Safety
- QL1.3 Improve Construction Safety
- QL1.4 Minimize Noise & Vibration
- QL1.5 Minimize Light Pollution
- QL1.6 Minimize Construction Impacts

MOBILITY

- QL2.1 Improve Community Mobility & Access
- QL2.2 Encourage Sustainable Transportation
- QL2.3 Improve Access & Wayfinding

COMMUNITY

- QL3.1 Advance Equity & Social Justice
- QL3.2 Preserve Historic & Cultural Resources
- QL3.3 Enhance Views & Local Character
- QL3.4 Enhance Public Space & Amenities

QL0.0 Innovate or Exceed Credit Requirement

COLLABORATION

- LD1.1 Provide Effective Leadership & Commitment
- LD1.2 Foster Collaboration & Teamwork
- LD1.3 Provide for Stakeholder Involvement
- LD1.4 Pursue Byproduct Synergies

PLANNING

- LD2.1 Establish a Sustainability Management Plan
- LD2.2 Plan for Sustainable Communities
- LD2.3 Plan for Long-Term Monitoring & Maintenance
- LD2.4 Plan for End-of-Life

ECONOMY

- LD3.1 Stimulate Economic Prosperity & Development
- LD3.2 Develop Local Skills & Capabilities
- LD3.3 Conduct a Life-Cycle Economic Evaluation
- LD0.0 Innovate or Exceed Credit Requirements

MATERIALS

- RA1.1 Support Sustainable Procurement Practices
- RA1.2 Use Recycled Materials
- RA1.3 Reduce Operational Waste
- RA1.4 Reduce Construction Waste
- RA1.5 Balance Earthwork On Site

ENERGY

- RA2.1 Reduce Operational Energy Consumption
- RA2.2 Reduce Construction Energy Consumption
- RA2.3 Use Renewable Energy
- RA2.4 Commission & Monitor Energy Systems

WATER

- RA3.1 Preserve Water Resources
- RA3.2 Reduce Operational Water Consumption
- RA3.3 Reduce Construction Water Consumption
- RA3.4 Monitor Water Systems

RA0.0 Innovate or Exceed Credit Requirements

SITING

- NW1.1 Preserve Sites of High Ecological Value
- NW1.2 Provide Wetland & Surface Water Buffers
- NW1.3 Preserve Prime Farmland
- NW1.4 Preserve Undeveloped Land

CONSERVATION

- NW2.1 Reclaim Brownfields
- NW2.2 Manage Stormwater
- NW2.3 Reduce Pesticide & Fertilizer Impacts
- NW2.4 Protect Surface & Groundwater Quality

ECOLOGY

- NW3.1 Enhance Functional Habitats
- NW3.2 Enhance Wetland & Surface Water Functions
- NW3.3 Maintain Floodplain Functions
- NW3.4 Control Invasive Species
- NW3.5 Protect Soil Health

NW0.0 Innovate or Exceed Credit Requirements

EMISSIONS

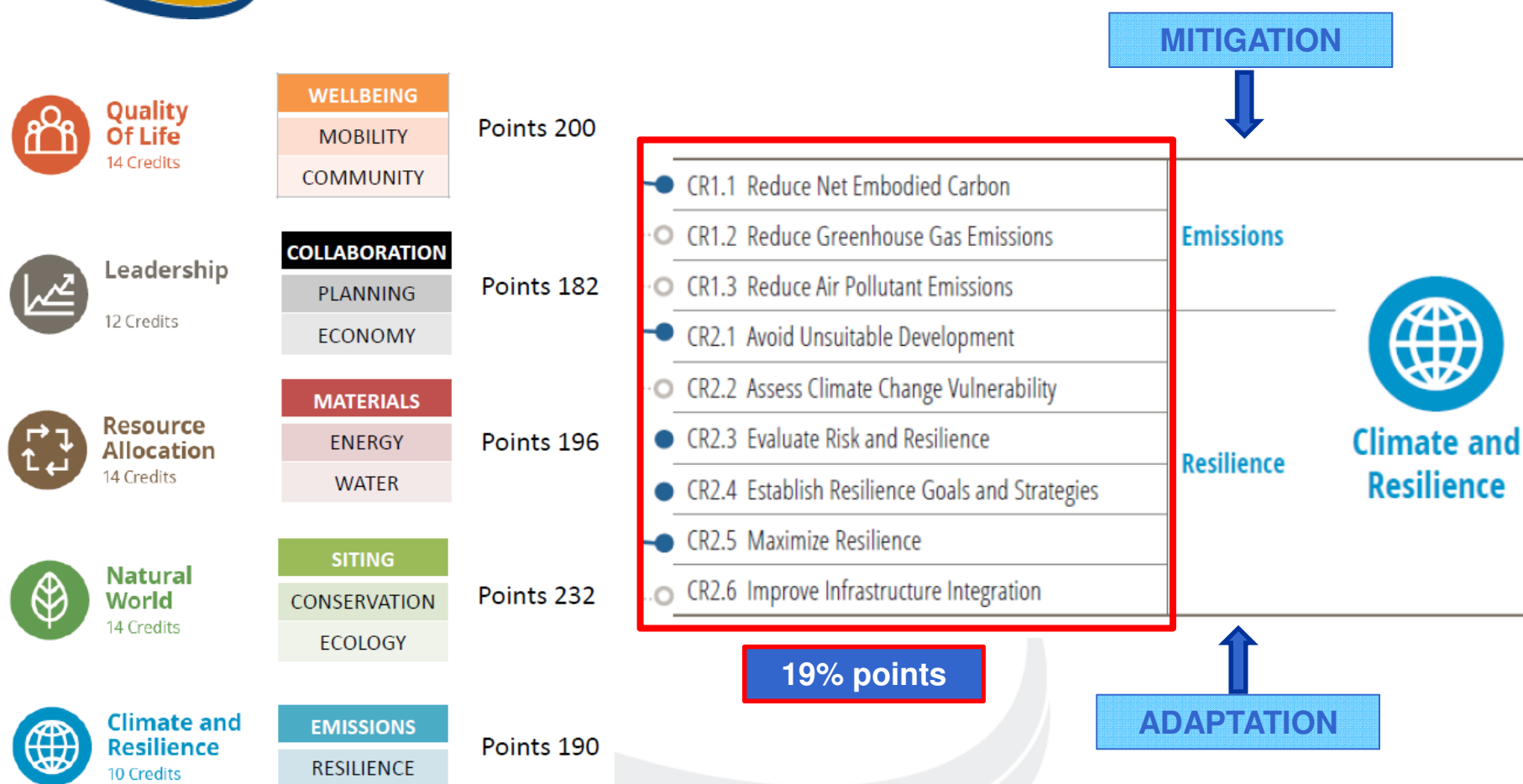
- CR1.1 Reduce Net Embodied Carbon
- CR1.2 Reduce Greenhouse Gas Emissions
- CR1.3 Reduce Air Pollutant Emissions

RESILIENCE

- CR2.1 Avoid Unsuitable Development
- CR2.2 Assess Climate Change Vulnerability
- CR2.3 Evaluate Risk & Resilience
- CR2.4 Establish Resilience Goals and Strategies
- CR2.5 Maximize Resilience
- CR2.6 Improve Infrastructure Integration

CR0.0 Innovate or Exceed Credit Requirements

Climate Change in ENVISION (1)



Influence of climatic changes on infrastructures design, construction and management

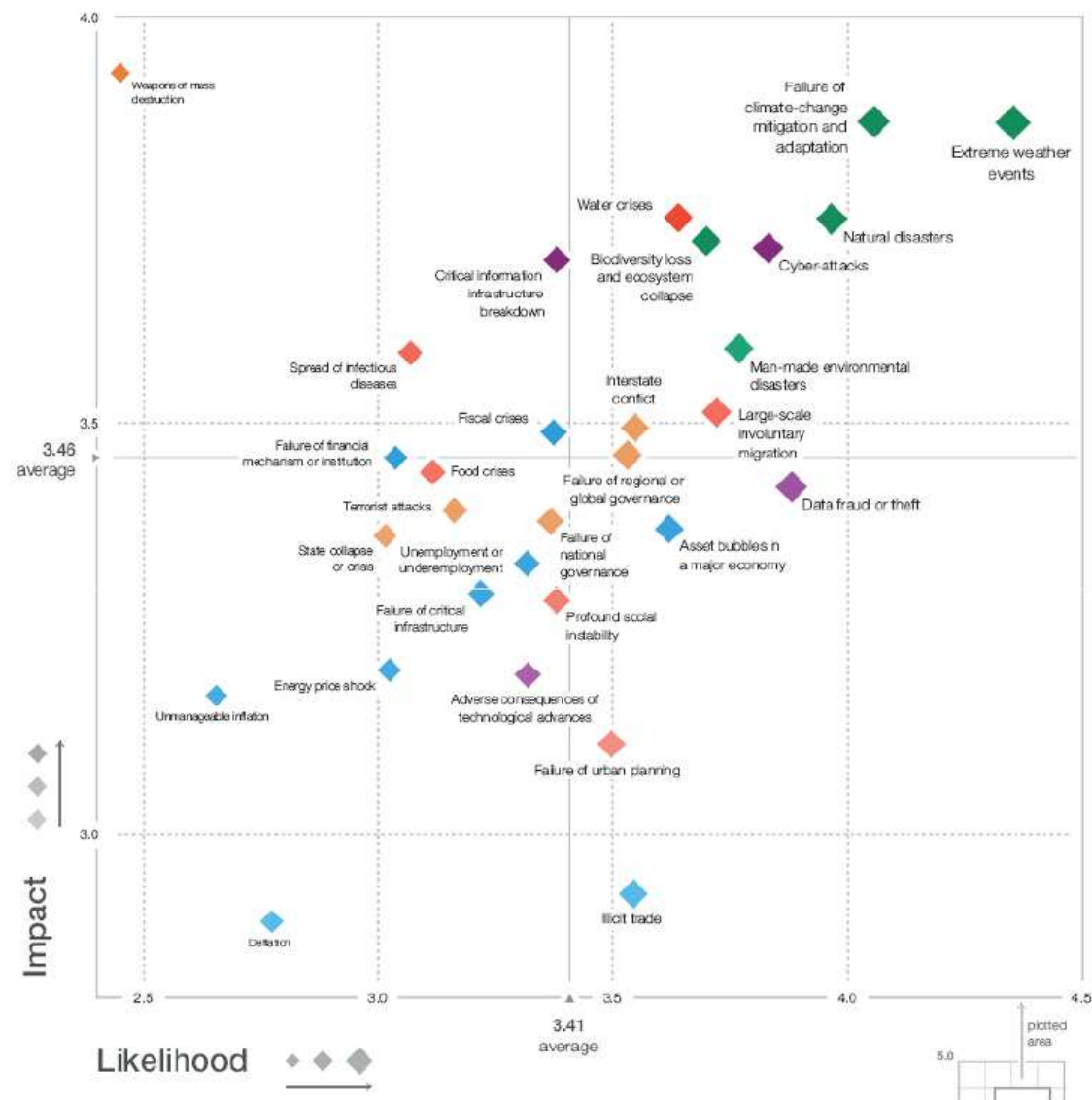
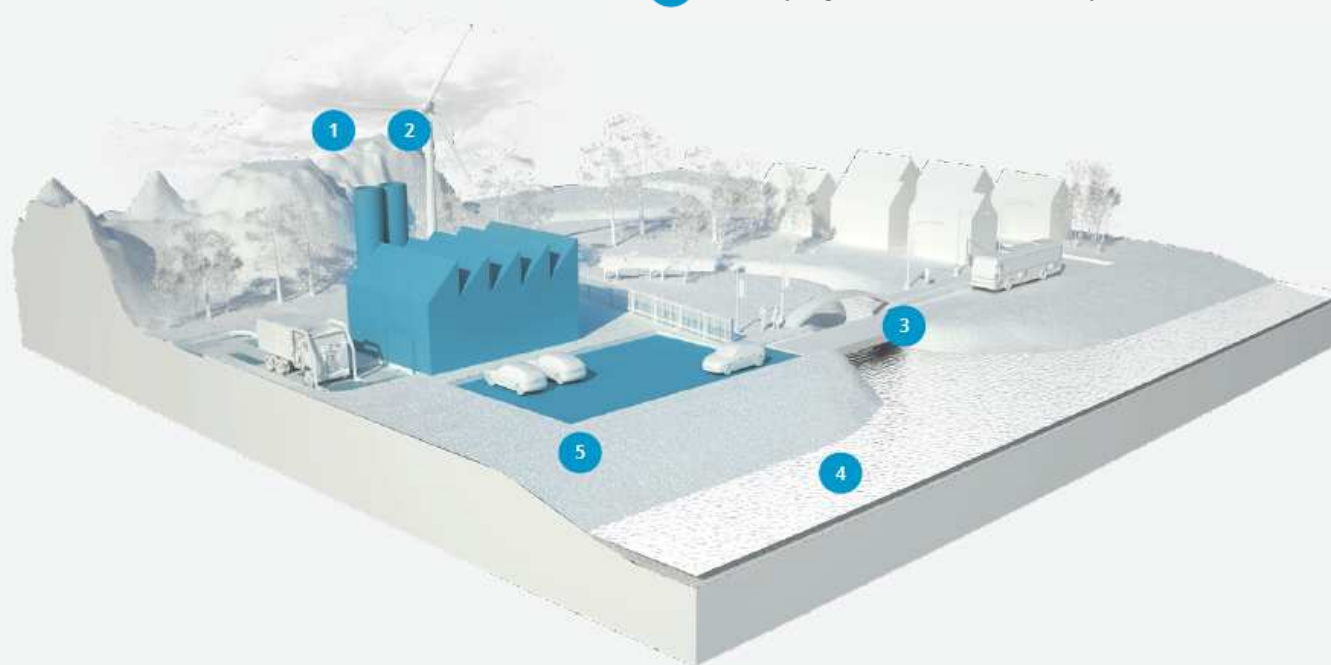


Figure I: The Global Risks Landscape 2019

Climate Change in ENVISION (2)

- 1 Does the project reduce greenhouse gas emissions?
- 2 Does the project reduce air pollutant emissions?
- 3 Does the project avoid unsuitable sites?
- 4 Does the project reduce climate change vulnerability?
- 5 Is the project resilient and adaptable?



**For further questions and information, do not hesitate
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Climate Change Credits/Emissions (1)



CLIMATE AND RESILIENCE: EMISSIONS

CR1.1 Reduce Net Embodied Carbon

20
POINTS

INTENT

Reduce the impacts of material extraction, refinement/manufacture, and transport over the project life.

METRIC

Percentage of reduction in net embodied carbon of materials.

LEVELS OF ACHIEVEMENT

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
A + B + C	A + B + C	A + B + C	A + B + C	Not Available
(5) At Least 5% Reduction	(10) At Least 15% Reduction	(15) At Least 30% Reduction	(20) At Least 50% Reduction	
(A) The project team identifies primary materials to be used on the project during construction and operation. The team determines which materials are the primary contributors to net embodied carbon (collectively >80%).				
(B) Embodied carbon is calculated, or acquired by a validated source, for the primary materials identified in criterion A. Calculations include: <ul style="list-style-type: none">• Embodied carbon of production, including raw material extraction, refinement, and manufacture.• Embodied carbon of transporting materials to the project site.• The replacement, repair, or refurbishment of materials over the life of the project.				
(C) The project team demonstrates at least a 5% reduction in total embodied carbon of materials over the life of the project compared to the baseline. Calculations should be in tons CO ₂ .	(C) The project team demonstrates at least a 15% reduction in total embodied carbon of materials over the life of the project compared to the baseline. Calculations should be in tons CO ₂ .	(C) The project team demonstrates at least a 30% reduction in total embodied carbon of materials over the life of the project compared to the baseline. Calculations should be in tons CO ₂ .	(C) The project team demonstrates at least a 50% reduction in total embodied carbon of materials over the life of the project compared to the baseline. Calculations should be in tons CO ₂ .	

Climate Change Credits/Emissions (2)



CLIMATE AND RESILIENCE: EMISSIONS

CR1.2 Reduce Greenhouse Gas Emissions

26
POINTS

INTENT

Reduce greenhouse gas emissions during the operation of the project, reducing project contribution to climate change.

METRIC

Percentage of reduction in operational greenhouse gas emissions.

LEVELS OF ACHIEVEMENT

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
A + B	A + B	A + B	A + B	A + B
(8) At Least 10% Reduction	(13) At Least 25% Reduction	(18) At least 50% Reduction	(22) 100% Reduction	(26) Carbon Negative
(A) The project team demonstrates at least a 10% reduction in total CO ₂ e over the operational life of the project compared to the baseline. Calculations should be in tons CO ₂ e.	(A) The project team demonstrates at least a 25% reduction in total CO ₂ e over the operational life of the project compared to the baseline. Calculations should be in tons CO ₂ e.	(A) The project team demonstrates at least a 50% reduction in total CO ₂ e over the operational life of the project compared to the baseline. Calculations should be in tons CO ₂ e.	(A) The project team demonstrates a 100% reduction in total CO ₂ e over the operational life of the project compared to the baseline. Calculations should be in tons CO ₂ e.	(A) The completed project is carbon negative (i.e., sequesters/removes more CO ₂ e than it produces over the operational life).
(B) The project team maps and calculates the total annual greenhouse gas emissions of the final project design for reporting purposes. This includes direct and indirect greenhouse gas emissions and sequestration associated with project operations. Calculations must be in CO ₂ e.				

Climate Change Credits/Emissions (3)



CLIMATE AND RESILIENCE: EMISSIONS

CR1.3 Reduce Air Pollutant Emissions

18

POINTS

INTENT

Reduce emissions of air pollutants: particulate matter (including dust), ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, lead, and volatile organic compounds.

METRIC

Reduction of air pollutants compared to baseline.

LEVELS OF ACHIEVEMENT

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
A + B	A + B + C	A + B + C + D	A + B + C + D	A + B + C + D + E
(2) Exceeding Requirements	(4) Ongoing Monitoring	(9) VOC Minimization	(14) Air Pollutant Elimination	(18) Air Quality Improvement
(A) The project meets all applicable air quality standards and regulations for air pollutants.				
(B) The project implements strategies to reduce air pollutant emissions during operations.	(B) The project reduces emissions through the use of best available control systems or best management practices.	(B) Air pollution controls are within the 95th percentile, or represent the lowest levels possible compared to projects of similar type.	(B) The project eliminates air pollutant sources in the design, chooses a non-polluting alternative, or achieves at least a 98% net reduction in air pollution emissions compared to the baseline.	
(C) Systems are in place for the ongoing monitoring of any direct sources of air pollution. Processes are in place to identify and address changes in emissions in order to maintain performance targets.				
(D) The project team assesses whether volatile organic compounds harmful to human health are material to the project and, if so, implement strategies to reduce their use during construction and/or within occupied spaces of the completed project.				
				(E) The project includes the direct removal of previously existing air pollutant sources, or captures and safely stores/ disposes of air pollutants for a net positive impact.

Climate Change Credits/Resilience (1)



CLIMATE AND RESILIENCE: RESILIENCE

CR2.1 Avoid Unsuitable Development

16

POINTS

INTENT

Minimize or avoid development on sites prone to hazards.

METRIC

The degree to which the project is designed and/or sited to avoid or mitigate site-related risks.

LEVELS OF ACHIEVEMENT

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
A + B	A + B + C	A + B + C + D	A + B + C + E	A + B + C + F
(3) Alternative Assessment	(6) Risk Mitigation	(8) Lowest Risk Alternative	(12) Unsuitable Development Avoided	(16) Strategic Retreat
<p>(A) During planning and project siting, the project team identifies potential siting hazards and determines both the vulnerability of the project to the hazard and the potential for the project to exacerbate the hazard (e.g., creating impervious surfaces in a floodplain, building on potentially unstable hillsides). Potentially adverse sites include but are not limited to:</p> <ul style="list-style-type: none"> • Steep slopes (> 20 degrees) • Permafrost • Adverse geology (e.g., risk of liquefaction, subsidence, or sinkholes) • Flood-prone areas • At-risk coastline (coastal surges, coastal erosion) <p>(B) The project team assesses siting alternatives that avoid or minimize hazard exposure and/or project alternatives less vulnerable to, or likely to exacerbate, site hazards.</p>				
		<p>(C) The project includes specific strategies to mitigate the impact of site hazards on the project (e.g., elevating structures and equipment above flood levels), as well as the project development impacts on the site hazard (e.g., erosion controls on steep slopes). This may include monitoring and response plans.</p>		
		<p>(D) Based on alternatives identified in criterion C, the project team can demonstrate the selected project and site resulting in the lowest exposure to site risk while still meeting project objectives and requirements.</p>	<p>(E) The project is intentionally sited to completely avoid site hazards.</p>	<p>(F) The project intentionally modifies or removes existing structures from areas prone to frequent damage and/or at high risk of future damage in order to prevent losses.</p>

Climate Change Credits/Resilience (2)



CLIMATE AND RESILIENCE: RESILIENCE

CR2.2 Assess Climate Change Vulnerability

20

POINTS

INTENT

Develop a comprehensive climate change vulnerability assessment.

METRIC

Scope and comprehensiveness of climate change vulnerability assessment.

LEVELS OF ACHIEVEMENT

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
A + B	A + B + C	A + B + C + D	A + B + C + D + E	Not Available
(8) Project Vulnerability	(14) System Vulnerability	(18) Community Vulnerability	(20) Knowledge Sharing	
<p>(A) The project team conducts, or relies on, an existing, comprehensive threat/hazard identification study, or assessment, due to climate change. Threats/hazards are classified by:</p> <ul style="list-style-type: none">• Duration: acute shocks over hours and days, or chronic stressors over years and decades.• Extent of effects: project site (e.g., localized stormwater overflow), infrastructure system wide, or community wide (e.g., changes in climate). <p>The assessment should account for climate change's impact on the frequency, duration, and severity of threats/hazards.</p> <p>(B) The project team determines vulnerabilities and increased risk to the project, or performance, over its operational life due to climate change-related threats. This should include whether current design variables will continue to meet performance goals over the life of the project under changing operating conditions (i.e., climate, weather patterns, natural hazard frequency and intensity).</p>				
<p>(C) The project team determines vulnerabilities and increased risk to the connected/related infrastructure system or network due to climate change-related threats. This should include how project vulnerabilities may impact system performance and how system vulnerabilities may impact the project. This should include direct and indirect impacts such as resource and service availability.</p>				
<p>(D) The project team determines vulnerabilities and increased risk to the broader community due to climate change threats. This should include how project vulnerabilities may impact the broader community and how community vulnerabilities may impact the project.</p>				
<p>(E) The project team or owner shares climate threat findings in order to support and facilitate community awareness and their inclusion in future projects.</p>				

Climate Change Credits/Resilience (3)



CLIMATE AND RESILIENCE: RESILIENCE

CR2.3 Evaluate Risk and Resilience

26

POINTS

INTENT

Conduct a comprehensive, multihazard risk and resilience evaluation.

METRIC

Scope and comprehensiveness of the multihazard risk and resilience evaluation.

LEVELS OF ACHIEVEMENT

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
A + B + C + D + E	A + B + C + D + E	A + B + C + D + E	A + B + C + D + E + F	NOT AVAILABLE
(11) Project Evaluation	(18) System Evaluation	(24) Community Evaluation	(26) Integrated and Inclusive Approach	
(A) The project team draws the assessment boundary for subsequent criteria (B, C, D, and E) around the project and its site.	(A) The project team draws the assessment boundary for subsequent criteria (B, C, D, and E) around the interdependencies of the project and its associated/connected infrastructure system/network.	(A) The project team draws the assessment boundary for subsequent criteria (B, C, D, and E) around the interdependencies of the project, its associated/connected infrastructure system/network, and the broader community.		
<p>(B) Understand the Asset: The project team identifies the objectives and performance goals of the project and related systems. It also identifies the critical assets, systems, and networks that are essential to meeting objectives and performance goals. This should include the associated dependencies and interdependencies within the system.</p> <p>(C) Identify Threats/Hazards: The project team identifies threats/hazards (natural hazards and human-induced threats). Project teams may reference existing studies or assessments if relevant to the project and its context. Threats should include both acute shocks and chronic stressors.</p> <p>(D) Identify Vulnerability: The project team identifies the vulnerabilities of the critical functions and dependencies of the infrastructure asset and its primary components identified in criterion B to the threats/hazards identified in criterion C.</p> <p>(E) Evaluate Risk: The project team evaluates the project risk by determining the likelihood/probability of a threat/hazard occurring and the associated consequences/impacts. Consequences and impacts should be classified as social, environmental, and/or economic/financial.</p>				
			(F) The project team conducts the risk evaluation with the owner and a diverse and integrated team of key stakeholders.	

Climate Change Credits/Resilience (4)



CLIMATE AND RESILIENCE: RESILIENCE

CR2.4 Establish Resilience Goals and Strategies

20
POINTS

INTENT

To support increased project and community resilience through the establishment of clear objectives and goals.

METRIC

The degree to which resilience goals expand from initial commitments to quantifiable project objectives, long-term operating plans, and community-wide development plans.

LEVELS OF ACHIEVEMENT

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
Not Available	A + B	A + B + C	A + B + C + D	Not Available
	(8) Strategy Development	(14) Stakeholder Input	(20) Shared Community Goals	
	<p>(A) The project team determines the performance goals of the project and the owner's acceptable level of risk.</p> <p>(B) The project team uses the results of a risk evaluation (e.g., CR2.3) to develop risk management strategies that meet project performance goals and budget, and increase project resilience. The project team prioritizes strategies that result in the greatest reduction of risk within project cost constraints.</p>			
		<p>(C) The project team engages the owner and key stakeholders in developing or reviewing resilience goals and strategies.</p>		
			<p>(D) The project team aligns project resilience goals with broader community- or region-wide resilience goals and plans.</p> <p>OR</p> <p>If community resilience goals are lacking, the project team publicly shares its resilience goals in support of developing broader community goals.</p>	

Climate Change Credits/Resilience (5)



CLIMATE AND RESILIENCE: RESILIENCE

CR2.5 Maximize Resilience

26

POINTS

INTENT

Increase resilience, life-cycle system performance, and the ability to withstand hazards by maximizing durability.

METRIC

The degree to which the project incorporates elements that increase durability, the ability to withstand hazards, and extend useful life.

LEVELS OF ACHIEVEMENT

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
A + B	A + B + C	A + B + C + D	A + B + C + D + E	Not Available
(11) Improved Resilience Performance	(15) Thorough Implementation	(20) Ongoing Resilience Monitoring	(26) Quantifying Improvement	
(A) The project team develops resilience goals and strategies (e.g., CR2.4) based on a detailed risk evaluation of the project (e.g., CR2.3).				
(B) The project team takes a comprehensive approach to implementing resilience strategies.				
(C) The project team periodically monitors the implementation of resilience strategies and revisits their effectiveness in addressing project risk throughout project development.				
(D) Resilience strategies are incorporated into the operations and maintenance of the project. Organization(s) responsible for the ongoing operation of the project have systems in place to maintain, grow, learn, and continually improve resilience capabilities (i.e., "plan, do, check, act").				
(E) The project team establishes methods for measuring/quantifying the benefits of resilience strategies implemented (e.g., monetary savings from avoided damage or service loss, accelerated recovery time).				

Climate Change Credits/Resilience (6)



CLIMATE AND RESILIENCE: RESILIENCE

CR2.6 Improve Infrastructure Integration

18
POINTS

INTENT

Enhance the operational relationships and strengthen the functional integration of the project into connected, efficient, and diverse infrastructure systems.

METRIC

The degree to which the project is integrated into other connected systems, where beneficial and appropriate, in order to increase resilience and systems performance.

LEVELS OF ACHIEVEMENT

IMPROVED A	ENHANCED A + B	SUPERIOR A + B + C	CONSERVING A + B + C + D	RESTORATIVE A + B + C + D + E
(2) Internal Integration	(5) Risk Reduction	(9) Systems Integration	(13) Community/ Network Integration	(18) Information Integration
(A) The project increases internal systems integration in order to achieve efficiency or system diversity.				
(B) Integration strategies increase resilience and reduce the risk of systemic or cascading failures.				
(C) The project leverages its relationship within a larger infrastructure system in order to achieve efficiency or system diversity.				
(D) The project integrates networks of infrastructure systems (e.g., water and transportation) in order to achieve efficiency or system diversity. In certain cases, projects may substitute the community integration of non-physical social or economic systems.				
(E) The project integrates data or monitoring systems with reporting or preparedness systems in order to learn and improve performance over time.				

Climate Change Credits/Resilience (7)



CLIMATE AND RESILIENCE: RESILIENCE

CR2.6 Improve Infrastructure Integration

18

POINTS

INTENT

Enhance the operational relationships and strengthen the functional integration of the project into connected, efficient, and diverse infrastructure systems.

METRIC

The degree to which the project is integrated into other connected systems, where beneficial and appropriate, in order to increase resilience and systems performance.

LEVELS OF ACHIEVEMENT

IMPROVED A	ENHANCED A + B	SUPERIOR A + B + C	CONSERVING A + B + C + D	RESTORATIVE A + B + C + D + E
(2) Internal Integration	(5) Risk Reduction	(9) Systems Integration	(13) Community/ Network Integration	(18) Information Integration
(A) The project increases internal systems integration in order to achieve efficiency or system diversity.				
(B) Integration strategies increase resilience and reduce the risk of systemic or cascading failures.				
(C) The project leverages its relationship within a larger infrastructure system in order to achieve efficiency or system diversity.				
(D) The project integrates networks of infrastructure systems (e.g., water and transportation) in order to achieve efficiency or system diversity. In certain cases, projects may substitute the community integration of non-physical social or economic systems.				
(E) The project integrates data or monitoring systems with reporting or preparedness systems in order to learn and improve performance over time.				

Climate Change Credits/Innovation



CLIMATE AND RESILIENCE: INNOVATION

CR0.0 Innovate or Exceed Credit Requirements

+10
POINTS

INTENT

To reward exceptional performance beyond the expectations of the system and application of innovative methods that advance state-of-the-art sustainable infrastructure.

METRIC

Whether project sustainability performance qualifies as innovation, exceptional performance, or is not otherwise recognized in existing credits.

LEVELS OF ACHIEVEMENT

INNOVATION
A or B or C
(+1-10) Innovate or Exceed Credit Requirements
<p>(A) Implement innovative methods, technologies, or processes that are novel either in their use, application, or within the local regulatory or cultural context.</p> <p>OR</p> <p>(B) Implement measures that exceed the highest existing requirements within one or more Climate and Resilience credits.</p> <p>OR</p> <p>(C) Address additional aspects of sustainability not currently recognized in Envision</p>

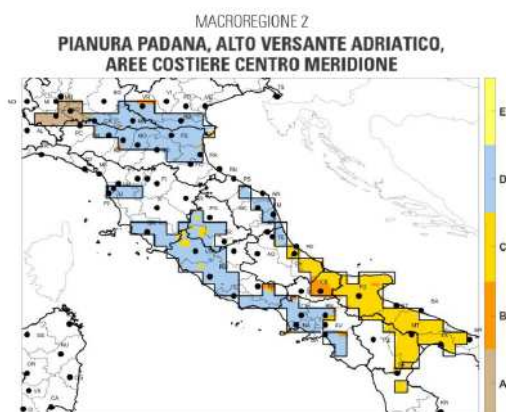
PNACC - Piano Nazionale per l'Adattamento ai Cambiamenti Climatici (Lug.2017)

- Caratterizzazione climatica italiana attuale e futura
→ 6 Macroregioni Climatiche Omogenee (1981-2010) *cluster analysis* 8 indicatori
- Analisi delle anomalie climatiche su temperature attese e precipitazioni medie stagionali
→ periodi: 2021-2050 & 2071-2100; scenari IPCC: RCP 4.5 e RCP 8.5
- Zonazione delle anomalie climatiche 2021-2050 (RCP 4.5 e RCP 8.5)
- Individuazione di 13 “AREE CLIMATICHE OMOGENEE”: aree con uguale condizione climatica attuale e stessa proiezione climatica di anomalia futura

RCP 4.5 - Aree climatiche omogenee: A, 2C, 2D.

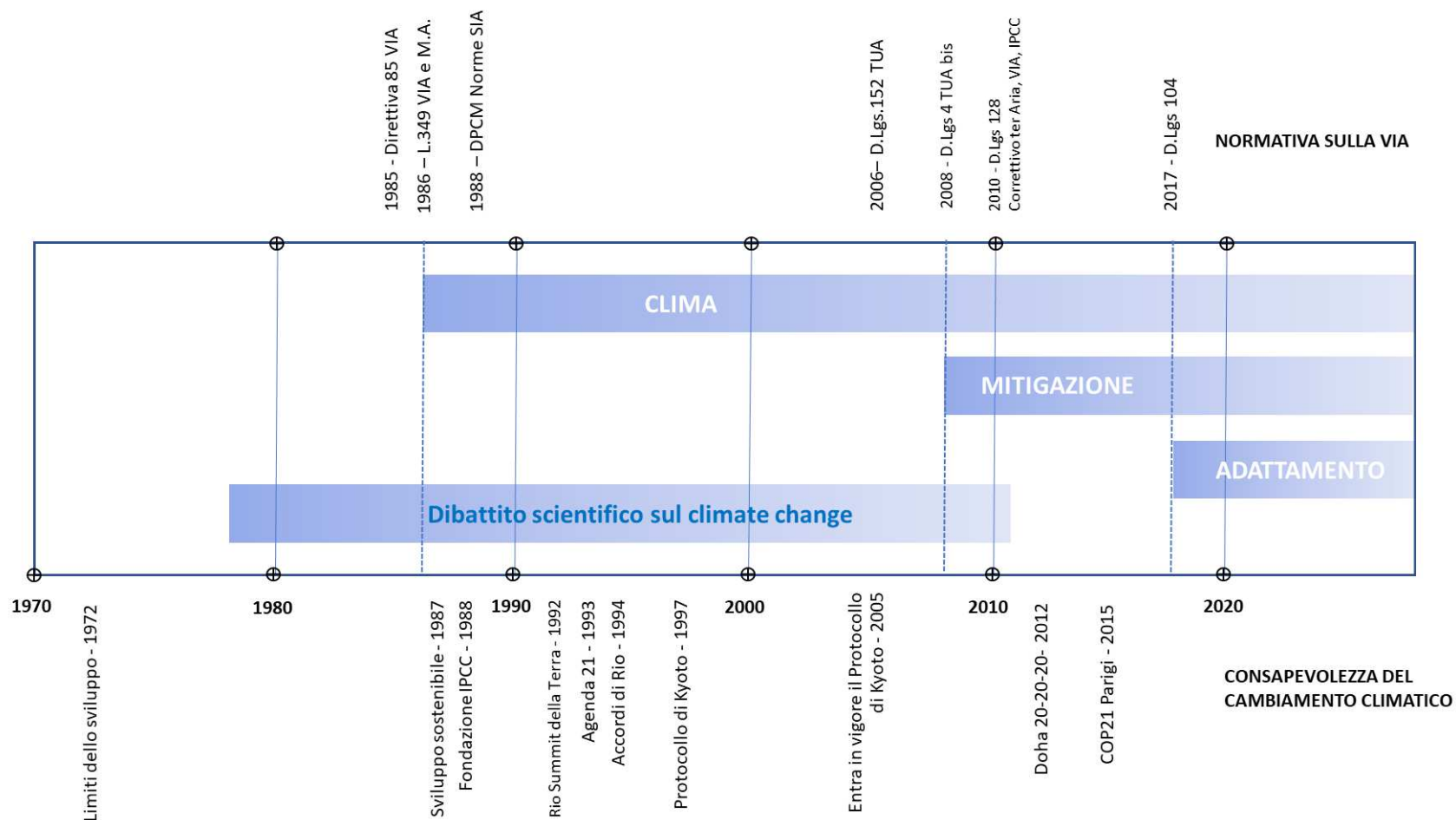
Anomalie principali: Le proiezioni indicano un aumento delle precipitazioni invernali e una riduzione di quelle estive per il versante tirrenico e la maggior parte della Pianura Padana. Per la parte ovest della pianura Padana e il versante adriatico, si evidenzia una riduzione sia delle precipitazioni estive che di quelle invernali. In generale si ha un aumento significativo dei giorni estivi per l'intera macroregione 2.

	A	C	D
Tmean (°C)	1.4	1.2	1.2
R20 (giorni/anno)	-1	0	1
FD (giorni/anno)	-20	-6	-9
SU95p (giorni/anno)	18	12	14
WP (mm) (%)	-4	-5	8
SP (mm) (%)	-27	-18	-25
SC (giorni/anno)	-12	-1	-1
Evap (mm/anno) (%)	-6	-3	-2
R95p (mm) (%)	1	4	11



Italia

The Italian Climate Change Roadmap



Influence of climatic changes on infrastructures design, construction and management