



Route III, Paraguay,
after torrential rains,
December 2015

Increasing Transport Resilience

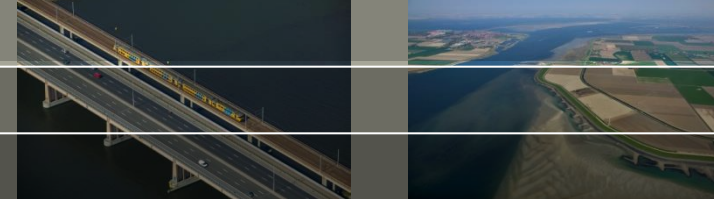
The ROADAPT framework in practice

Mike Woning

JASPERS Networking Platform Seminar
Climate Change Adaptation in the Transport Sector – Experience from
Project Preparation and Network Management

Brussels, 6th December 2017

Deltares facts and figures



- Legal form: Foundation under Dutch law
- Workforce: 840
- Number of nationalities: 28
- Annual turnover: 113 million euros
- Locations: Delft and Utrecht
- National and international activities
- Unique in-house facilities

Offices and registrations in: India, Singapore, Indonesia, USA, Brazil and UAE

Deltares

Geo-experimental facilities



Advanced geotechnical lab



Microbial en geochemical lab



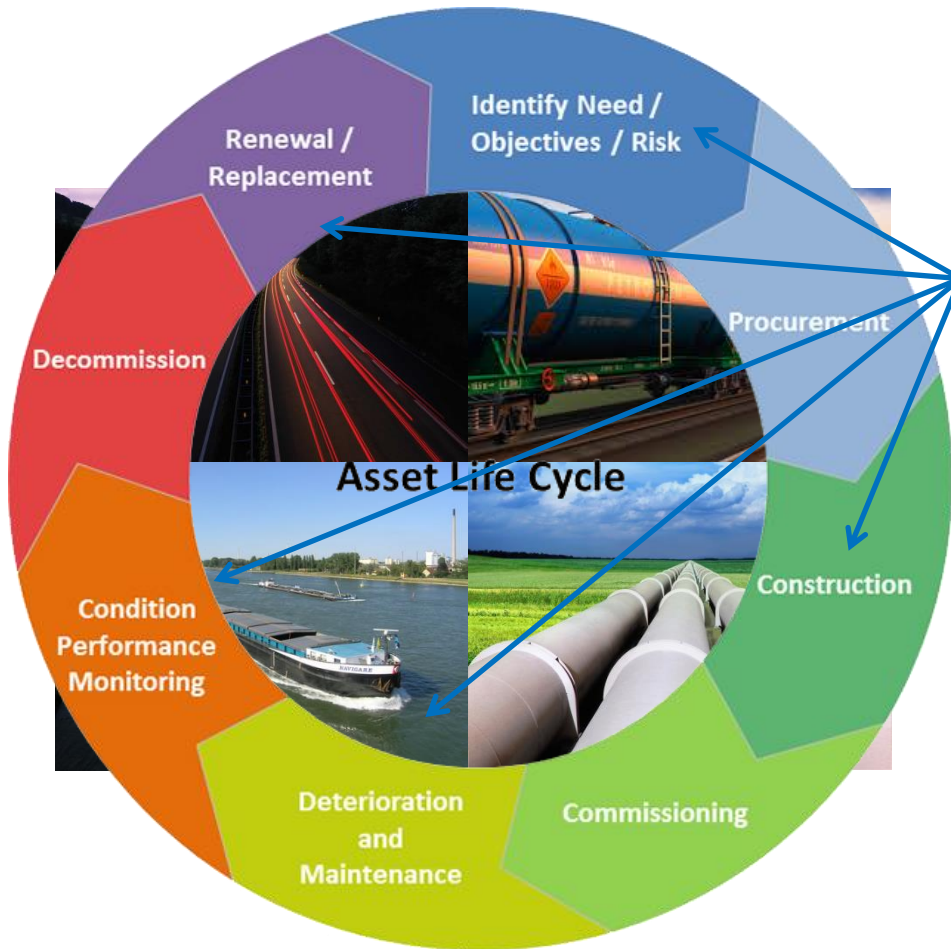
Geocentrifuge (ng)
for models (1g)



Test laboratorium
Deltares

Impact of weather and CC on assets

Asset life cycle



Weather



+ climate change

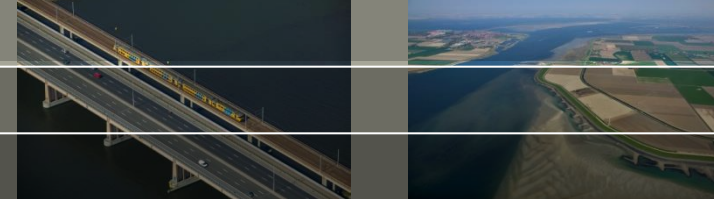


As a result...

- Extreme weather may have **significant impact** on (the use of) infrastructure
 - Weather is changing due to climate change: extreme events are becoming **extremes** and **more frequent**
- **More weather related unwanted events**
- **Increasing challenges for efficient Asset Management**



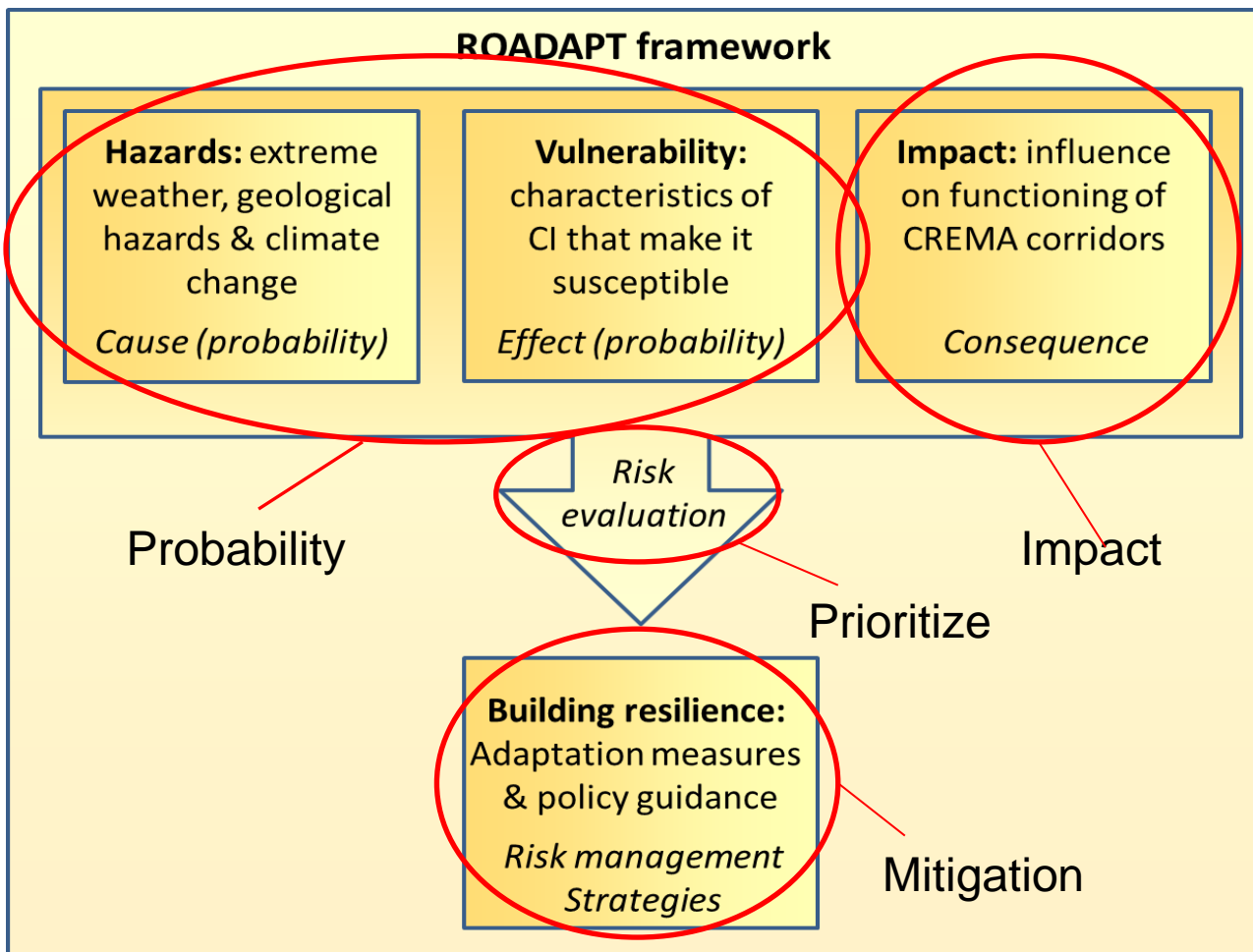
GOAL of presentation



Goal: share our experience with climate change & infrastructure projects

- Basics of method
- Examples of projects
 - *InnovA58, Netherlands; client National Road Authority*
 - *CREMA contracts, Paraguay; client National Road Authority & World Bank*
 - *Blue Areas, Netherlands; Prorail*
 - *Tuzla, Turkey; client Turkey: World Bank, Chamber of Industry*
- Questions?

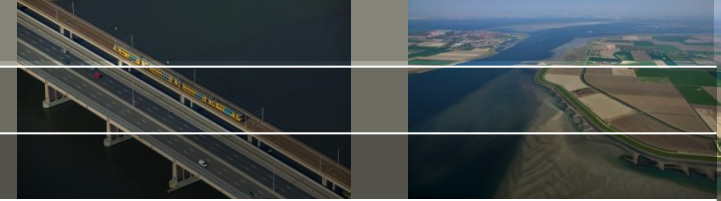
Fundamentals of ROADAPT method



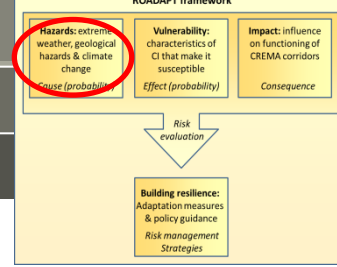
Approach:

- Use data/ information/ models if present
- Use expert local knowledge if not present (semi quantitative approach)

INTACT



Hazard - cause



WATCH project – current research

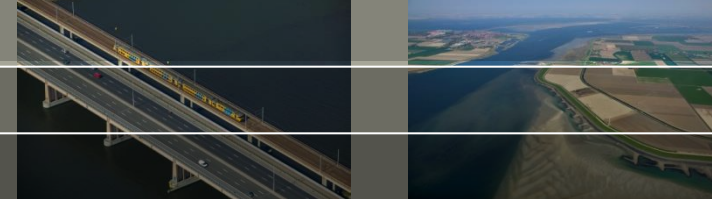


CEDR: most important high frequency causes of road flooding
Water in area around the road

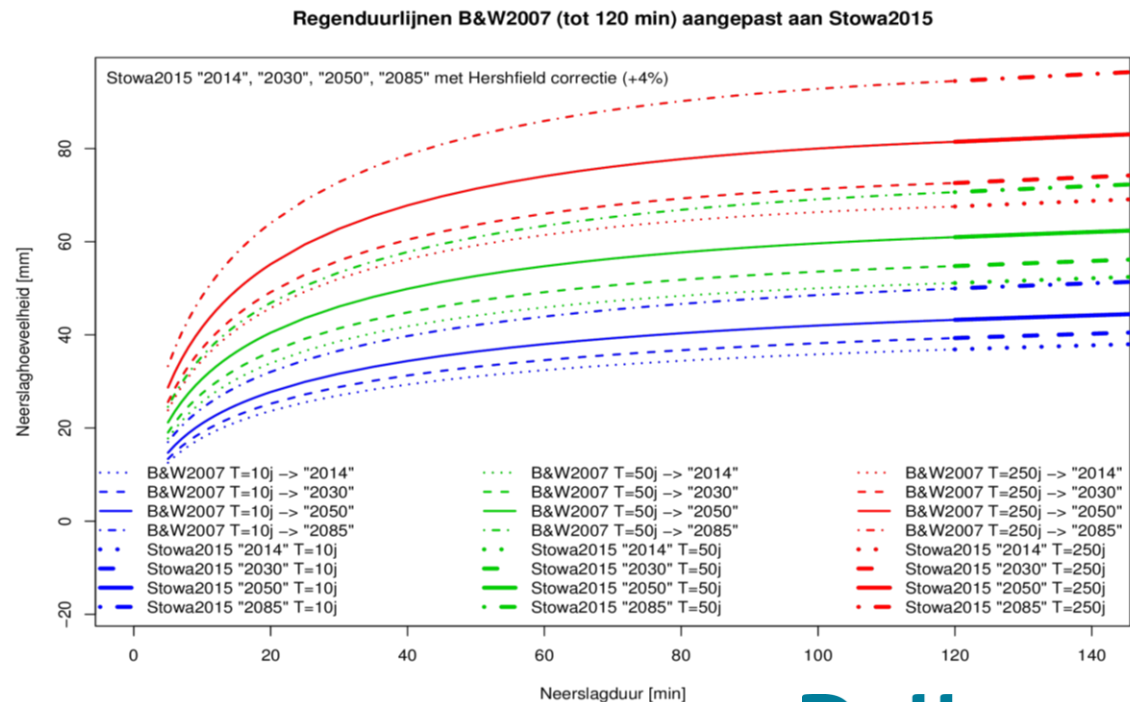
- Surface run-off
- Pluvial flooding

Heavy rain on the road itself

Climate change

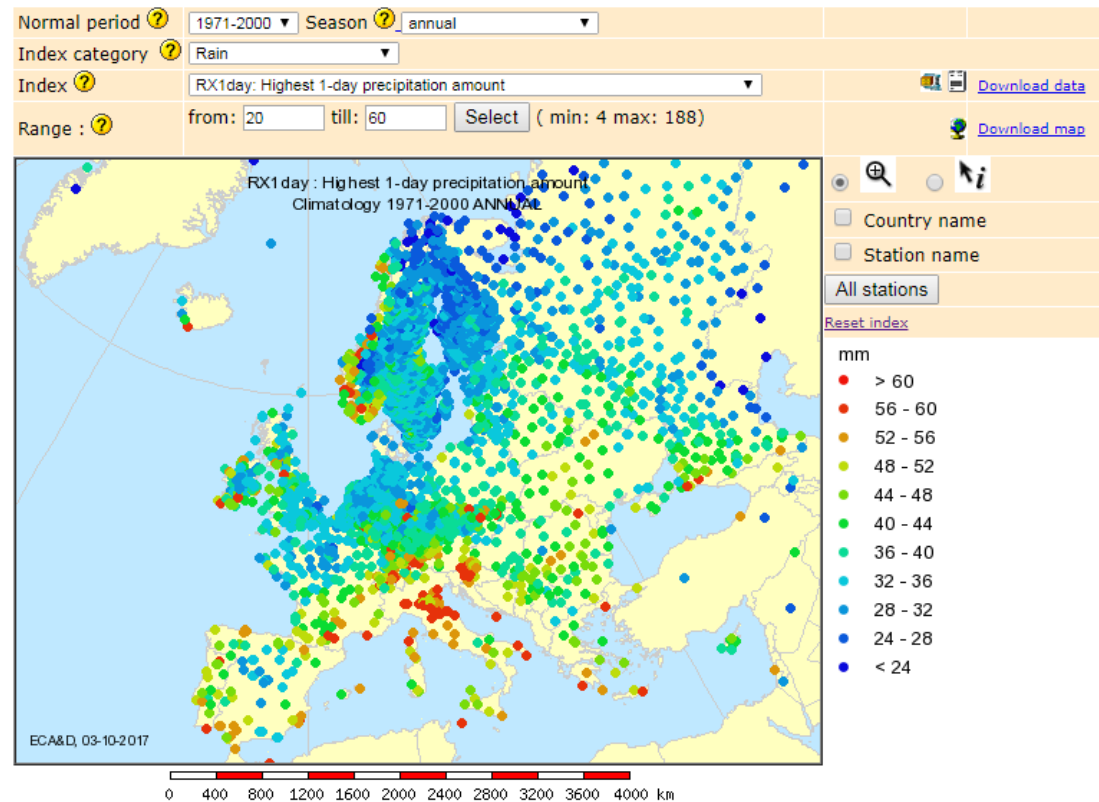


- Recommendations on how to derive IDF curves for both the current and future climate.
- Including recommendations to overcome the specific challenges of having no information on hourly rainfall data for the future
 - “7% increase of rainfall intensity per one degree increase of dew point temperature”



Climate change – analogues tool

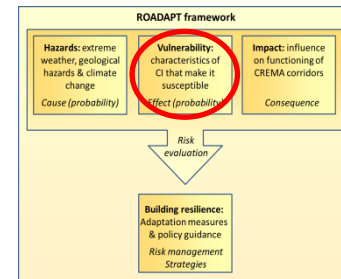
- Climate analogues tool plus guidance has been developed
- Only available for daily and five daily data
- Sub-daily data not available throughout Europe



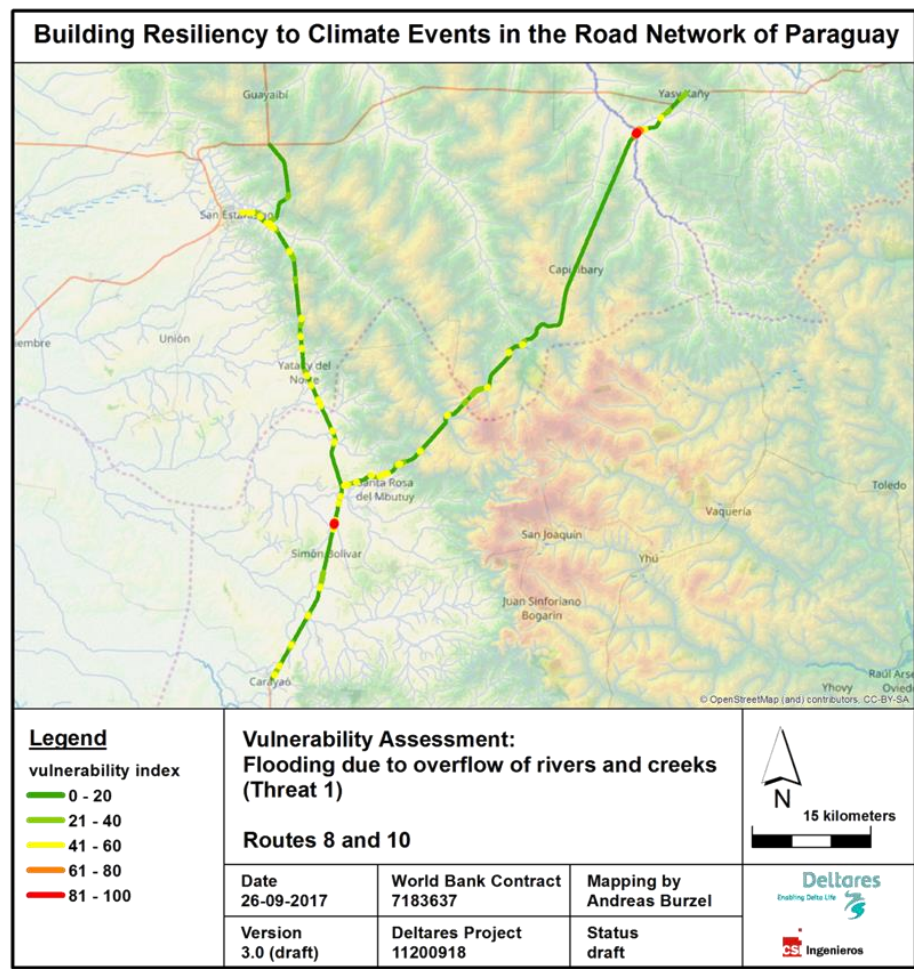
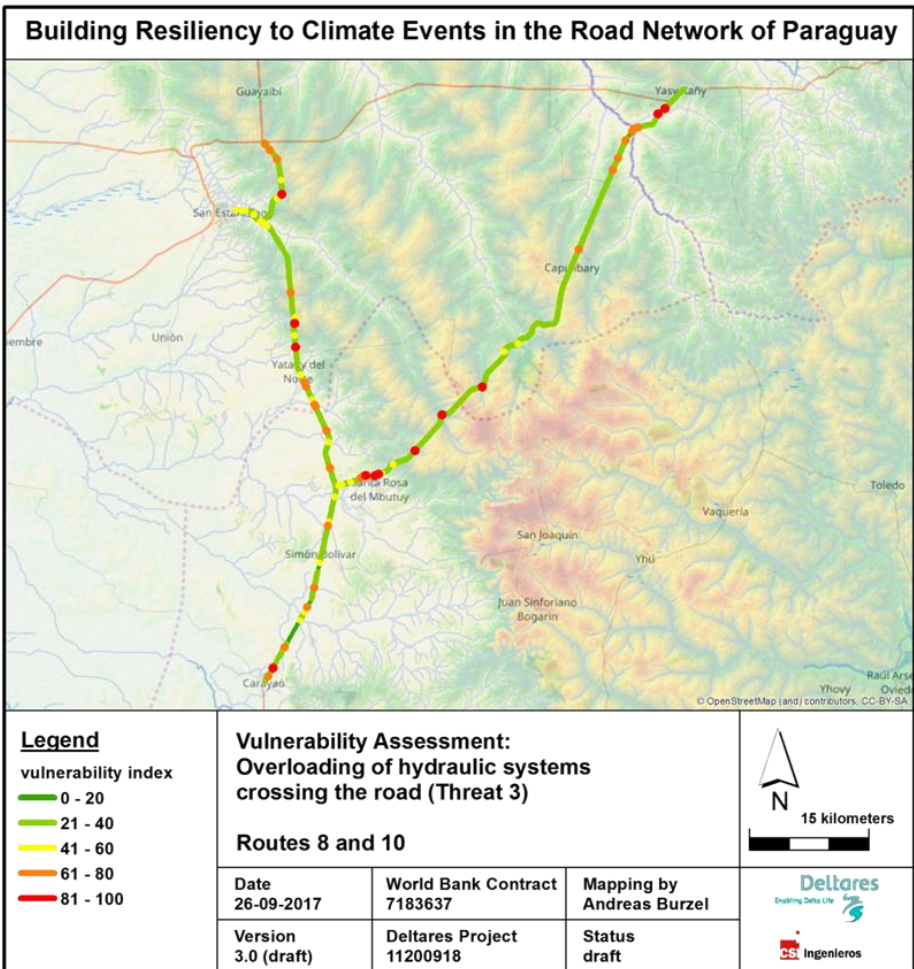
Vulnerability Assessment - probability

Goal: determine **where** the threats play a role

- Determine factors that influence the likelihood of a threat occurring (no modelling) in GIS environment
 - Road characteristics
 - Characteristics of surroundings
- Combine vulnerability factors to VA map



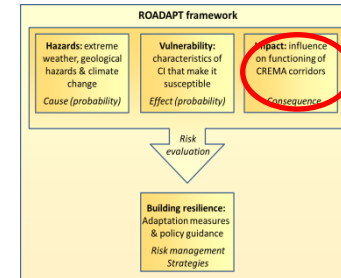
VA - Overloading of hydraulic systems crossing the road (threat 3)



Impact - consequence

(Workshop) criteria

Impact level	Safety	Availability	Repair cost
5 (very high)	Several casualties	The road is completely unavailable for a long period of time (months)	Inability to pay for extremely high repair costs by MOPC alone
4	Casualty	The road is completely unavailable for a limited period of time (weeks)	Repair cost exceed the reserves of MOPC
3	Heavy injuries	The road is completely unavailable for a short periode of time (days)	Repair cost exceeds yearly budget
2	Minor injuries	The road is partially unavailable for a short - limited period of time (days - weeks)	Part of expected exceptional maintenance and repair operations
1 (very low)	Only material damage	The road is partially available again within hours.	Part of routine maintenance



Interdependency of critical infrastructures

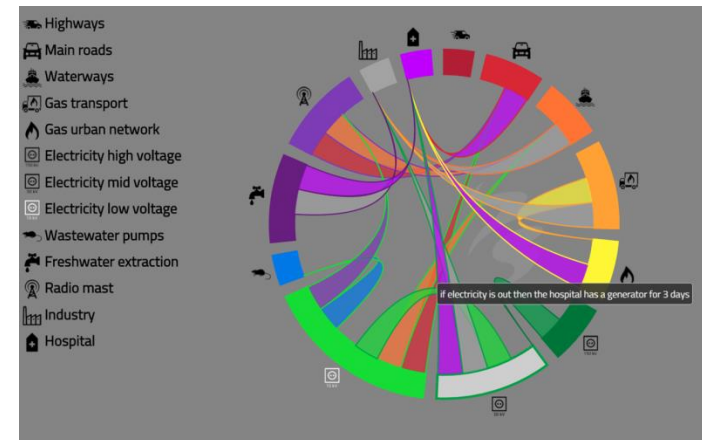


Table 0.3 Work (business) passenger trips (€₂₀₀₂ per passenger per hour, factor prices)

Country	Business		
	Air	Bus	Car, Train
EU (25 Countries)	32.80	19.11	23.82

Table 0.4 Non-work passenger trips (€₂₀₀₂ per passenger per hour, factor prices)

	Commuter-Short Distance			Commuter-Long Distance			Other-Short Distance			Other-Long Distance		
	Air	Bus	Car, train	Air	Bus	Car, train	Air	Bus	Car, train	Air	Bus	Car, train
EU (25 Countries)	12.65	6.10	8.48	16.25	7.83	10.89	10.61	5.11	7.11	13.62	6.56	9.13

Table 0.5 Freight trips (€₂₀₀₂ per freight tonne per hour, factor prices)

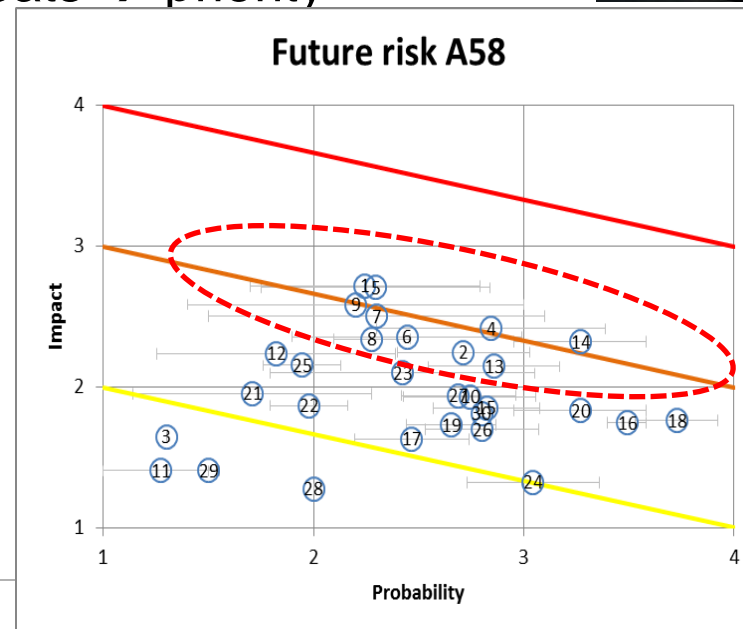
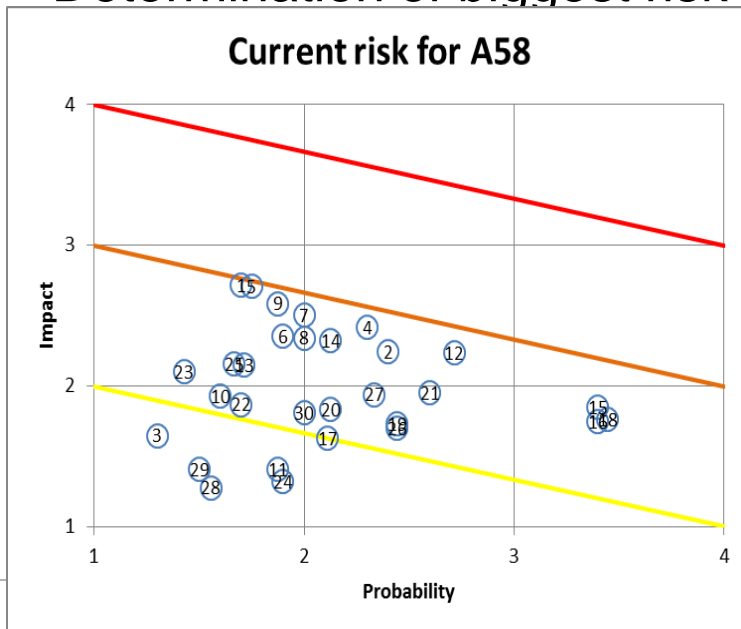
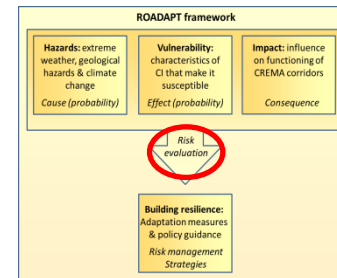
Country	Per tonne of freight carried ¹	
	Road	Rail
EU (25 Countries)	2.98	1.22

Extra travel time alternative routes + value of time

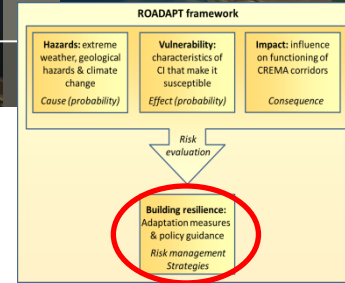
Risk Assessment/ Quick Scan - prioritize

Goal: **which threats** pose the biggest risk

- **Identify** relevant threats
- **Prioritize** by collaborative scoring of relevant threats
 - Impact (safety, availability, socio- economic, etc)
 - Current probability (historic events, expert judgement)
 - Determination of future probabilities (climate change)
- Determination of biggest risk threats → priority



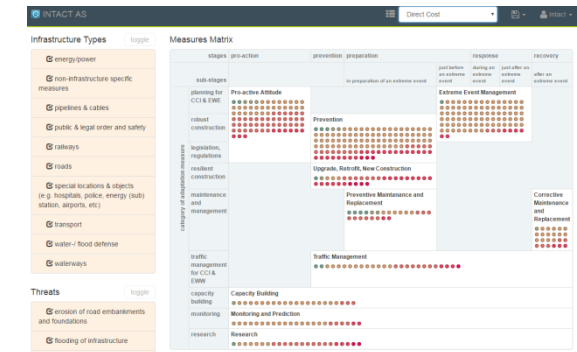
Adaptation Strategies - mitigation



Goal: plan measures (best strategy)

Steps:

- **Identify** (long list of) adaptation measures
 - Expert judgement
 - Workshops
 - Adaptation measures tool
- **Prioritize** adaptation measures using cost effectiveness Analysis → selection of ‘best measures’
- Combine best measures to form Adaptation strategies

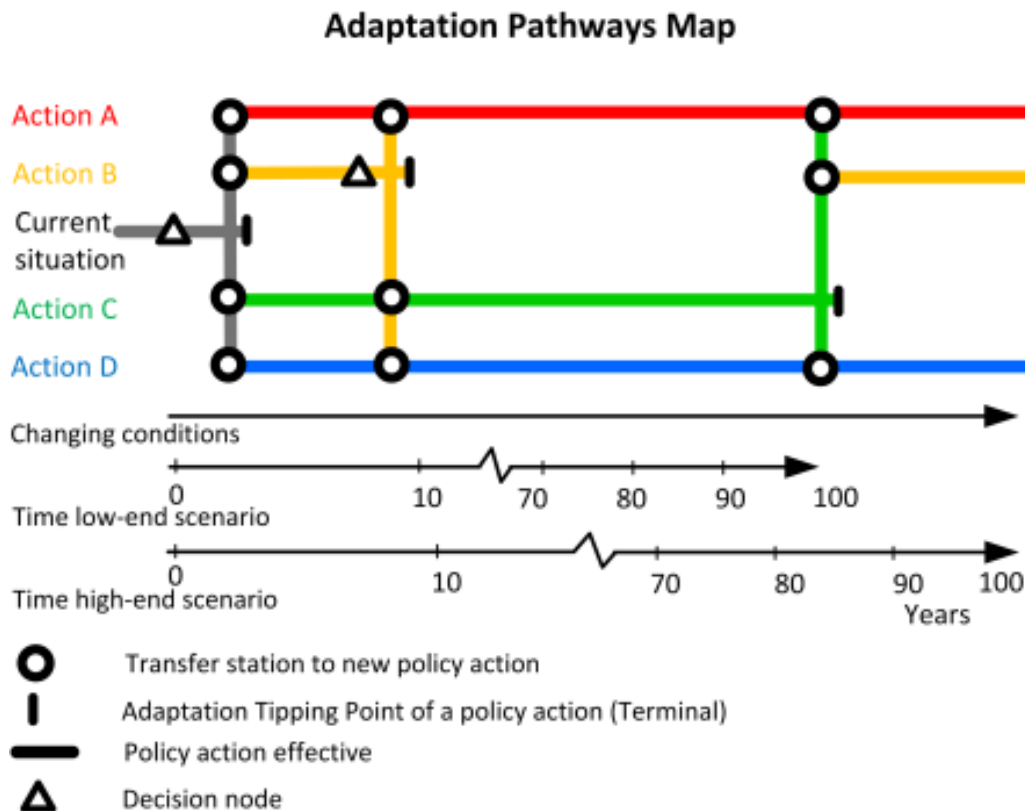


	Effectiveness (how well does the measure work) [0= 2000]	Costs (investment) when of an specific structure [€ 1000] (2 (low- 30kg) per km or location)	Technical lifespan [years]	Costs (operation and maintenance costs over the lifetime of the measure) can also be over a road network (i.e. area specific) [€ 1000] (2 (low- 30kg))	annual costs	Cost/benefit per kilometer (i.e. low = good)
Flooding due to overflowing of rivers and creeks						
Response plans (including making deposits, materials and equipment stand by)	75	10	15	1	1,96	0,96
Program and allocate road users and road authority staff for flooding	10	5	10	1	1,65	0,70
Integration of infrastructure development and land use planning	40	70	10	2	11,07	0,70
Warning signs on the level of water on the surface of the road (metric poles)	5	5	5	1	2,15	0,45
Keeping records of flooding events and locations	5	15	10	2,5	3,47	0,69
Cleaning out watercourses and structures of flood prone areas ahead of predicted heavy rainfall	5	15	10	2,5	6,44	0,80
Mapping areas prone to flooding (blue spot analysis)	25	100	10	1	25,07	1,00
Install signposts warning for flooding in threatened areas	2	5	5	1	2,15	0,98
Flood Warning Systems	10	100	10	100	22,95	1,11
Prepare contingency / emergency plans	10	100	10	1	11,95	1,15
Embankment elevation	15	700	10	1	411,83	4,15
Build flood walls to protect the road from flooding	15	700	10	1	461,83	4,15
Alternative routes (identification, maintain)	75	700	10	6	415,83	4,15
Design to increase depths and/or straighten the stream	5	1000	5	100	2.481,75	481,75



Adaptation Strategies - example

- Combination of best measures/ actions as function of time → Adaptation Strategy
- The map reads like a subway map, taking you from NOW to FUTURE



Costs and benefits of pathways

Time horizon 20 years
Time horizon 50 years
Time horizon 100 years

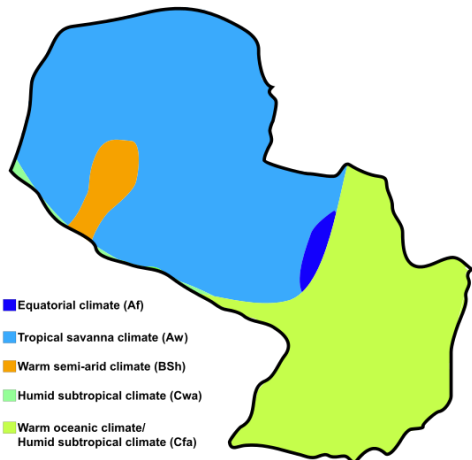
Pathway	Costs	Benefits	Co-benefits
1 ●	+++	+	0
2 ● ●	+++++	0	0
3 ● ●	+++	0	0
4 ● ●	+++	0	0
5 ●	0	0	-
6 ● ●	++++	0	-
7 ● ●	+++	0	-
8 ● ●	+	+	---
9 ●	++	+	---

Pathways that are not necessary in low-end scenario

CREMA contracts, Paraguay – at a glance



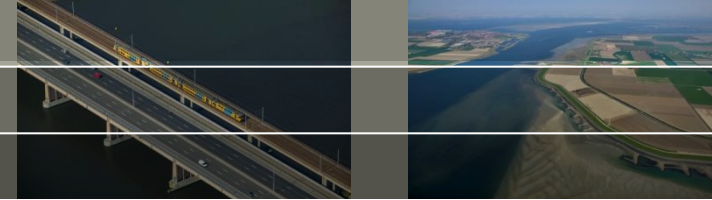
- Population: 6.7M
- Tropical - subtropical climate
- Landlocked, relies on agriculture and export → roads of vital importance
- El Nino has major impact → flooding, erosion
- Goal: provide a risk based, objective approach to help build resilience of road network



- Equatorial climate (Af)
- Tropical savanna climate (Aw)
- Warm semi-arid climate (BSH)
- Humid subtropical climate (Cwa)
- Warm oceanic climate/
Humid subtropical climate (Cfa)



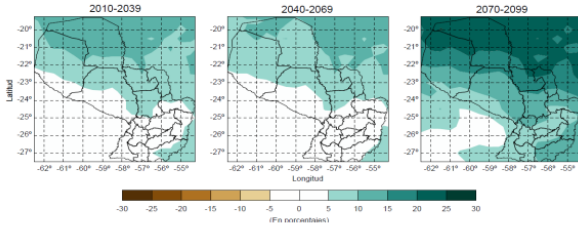
An impression of activities



Desktop study of existing information

	Total loss (US\$)	Category
1_1 San Juan Cnel. Bogado	3.284.176	Low
1_2 Cnel Bogado- Encarnación	3.342.198	Low
8_1 Carayao- Mbutuy	4.448.362	High
8_2 Mbutuy - Calle 6000	4.637.080	High
10_1 Mbutuy Yasi Cañy	3.150.366	Low

(Cambios porcentuales en comparación con la base histórica de 1961-1990)



Fuente: Economía del Cambio Climático en Paraguay, CEPAL 2014

- Road/ asset information
- Socio- economic
- Climate information

Site visit



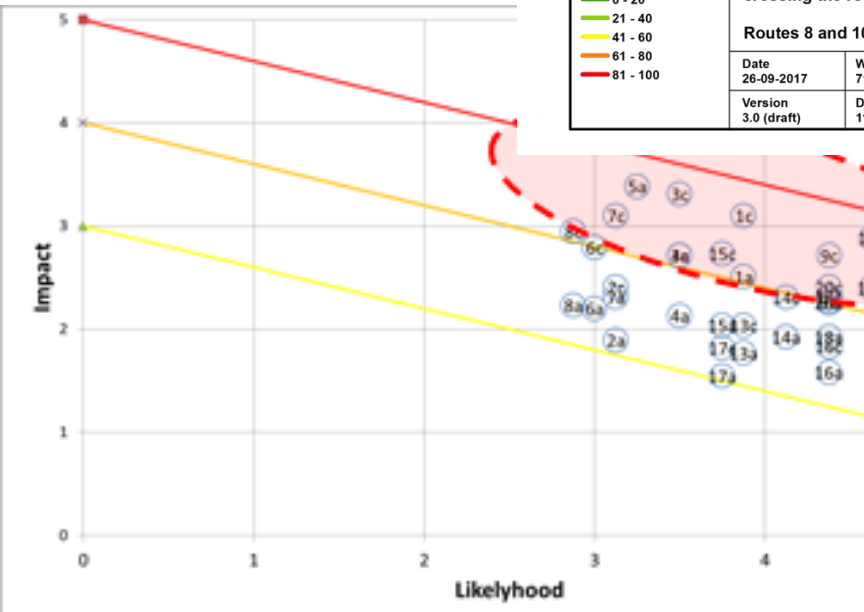
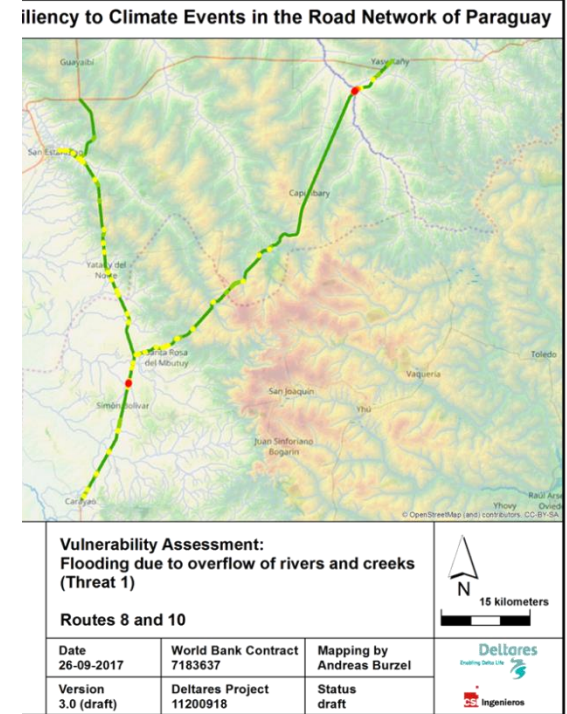
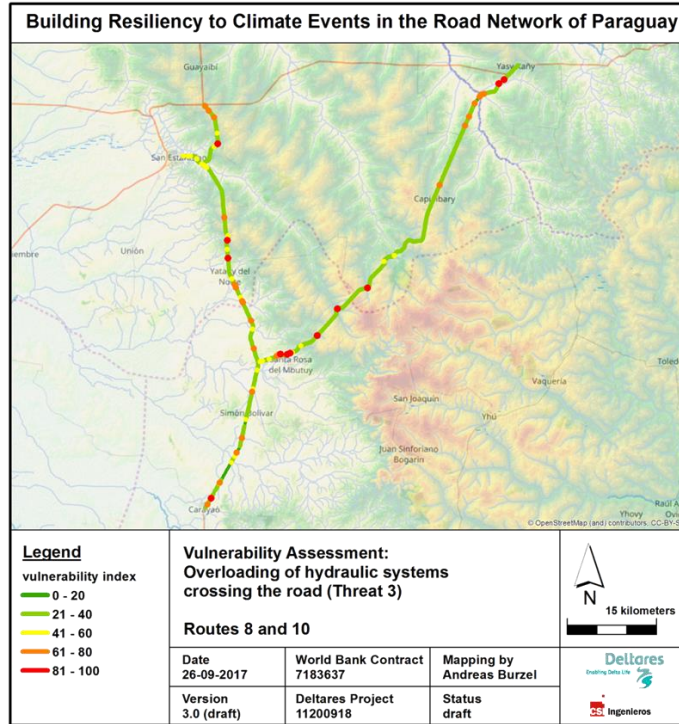
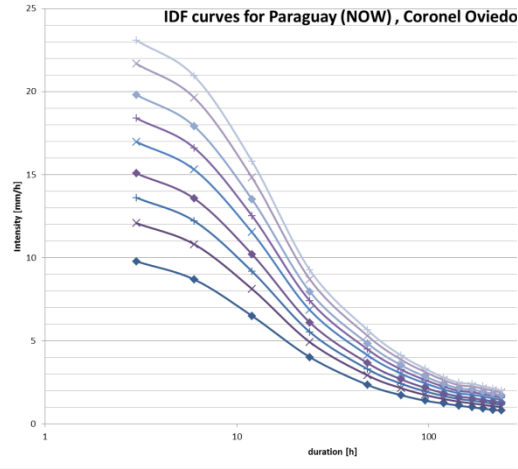
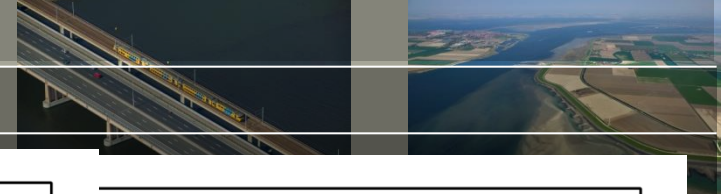
Workshops with local stakeholders



Nivel de Impacto	Seguridad	Disponibilidad	Costo de Reparación
5 (Muy alto)	Varios fallecidos	La carretera queda completamente indisponible por un largo periodo de tiempo (meses)	Los altos costos de reparación impiden que el MOPC pueda enfrentarlo con su presupuesto (se necesitan transferencias especiales del gobierno)
4	Fallecido	La carretera queda completamente indisponible por periodo de tiempo limitado (semanas)	El costo de reparación excede el presupuesto de mantenimiento a mediano plazo (se deben hacer transferencias internas de fondos)
3	Lesionados graves	La carretera queda completamente indisponible por un corto periodo de tiempo (días)	El costo de reparación excede el presupuesto de mantenimiento previsto para este lugar.
2	Lesionados leves	La carretera queda parcialmente indisponible por un periodo limitado (días a semanas)	Forma parte del presupuesto de mantenimiento y reparaciones excepcionales
1 (Muy Bajo)	Únicamente daños materiales	La carretera queda parcialmente disponible nuevamente en pocas horas.	Forma parte del presupuesto de mantenimiento de rutina

Probabilidad	Descripción
5 (Alto)	Periodo de Retorno menor a 5 años
4	5 – 20 años
3	20 – 50 años
2	50 – 200 años
1 (Bajo)	Periodo de Retorno mayor a 200 años

Impression of results

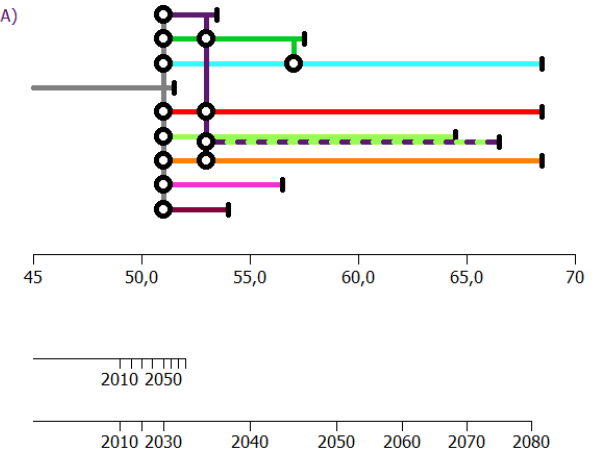


- Drainage via 7 cm thick porous layer (double layered PA)
- Drainage via 10 cm thick porous layer
- Drainage via 18 cm thick porous layer
- Current Situation (storage in PA taken into account)
- Enlarging capacity of stormwater drainage system
- Use of gutters instead of manholes
- Water storage under the road or in noise barrier
- Adaptive maintenance
- Ensuring levelness of longitudinal profile

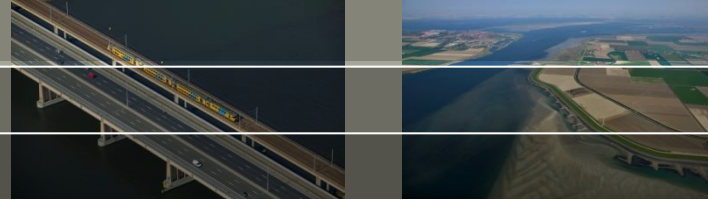
precipitation in 2 hours [mm]

G_L centre

W_H upper

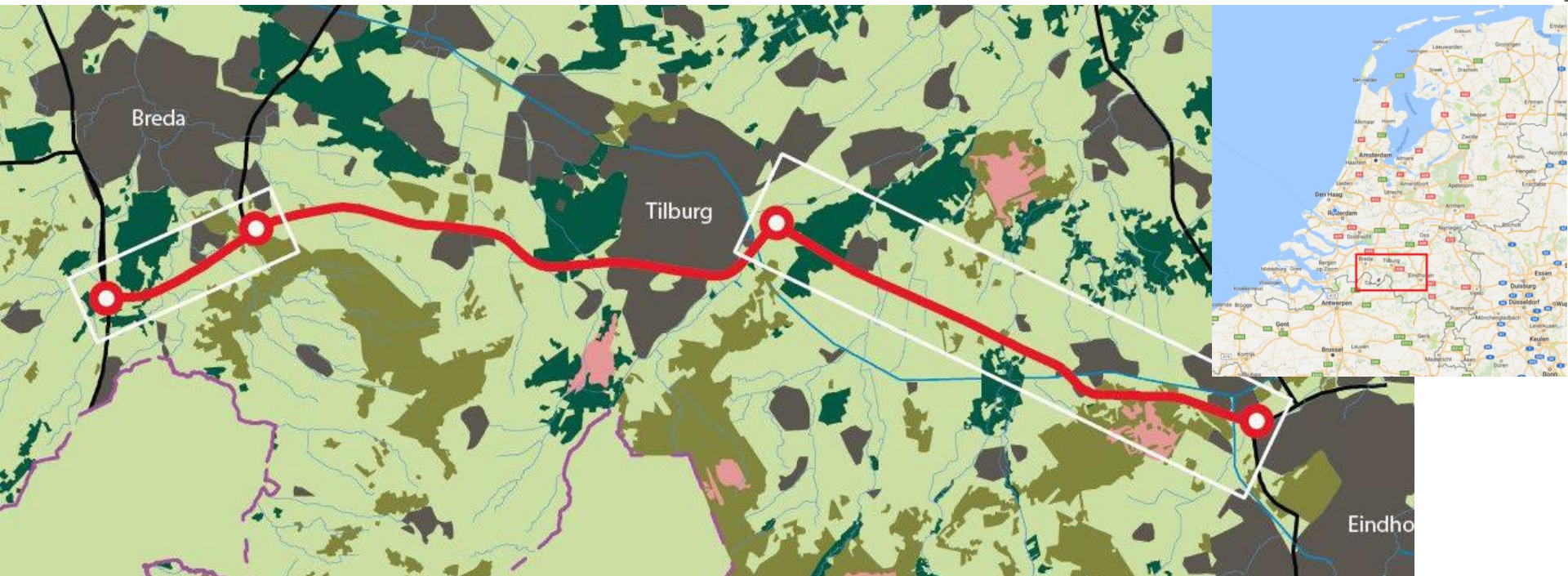


Paraguay – client value



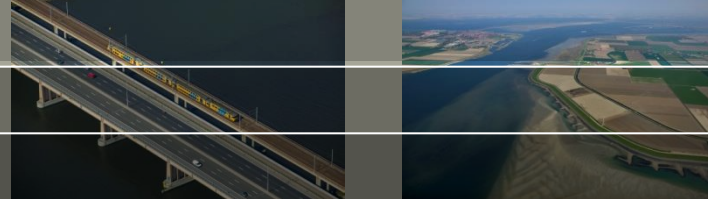
- Provide Adaptation Strategies i.e. various paths for building resilience for high risk threats
 - Provide recommendations for
 - Road Asset Management System
 - CREMA contracts
 - Alert & response plan
 - Training of local authorities
- Substantiate necessity of funding for alert & response plan
- More security World Bank loan
- Concrete and practical help for MOPC to make Paraguay road network more resilient, safer and reliable

InnovA58, Netherlands – at a glance



- Approximately 50km highway, important E – W connection
- Extra driving lanes planned (now is time to implement changes)
- (Relatively) rural area (flat), some cities/ towns, agriculture, forest/ nature, minor river/ streams
- Goal: find innovative solutions for climate change challenges for road AND surroundings

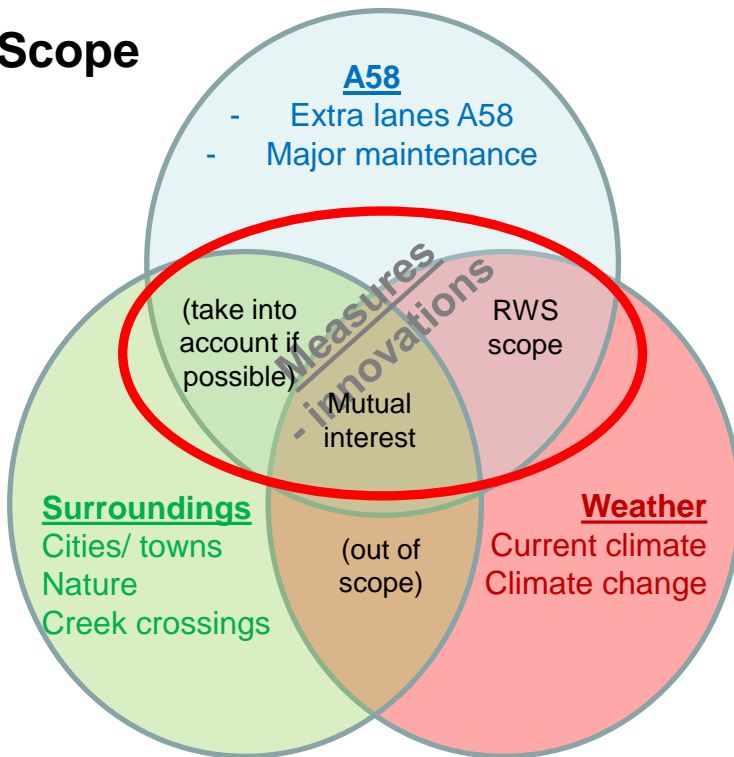
InnovA58 – an impression



Typical assets



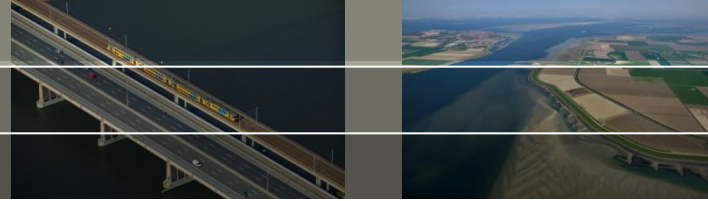
Scope



Workshops with stakeholders, scoring of threats



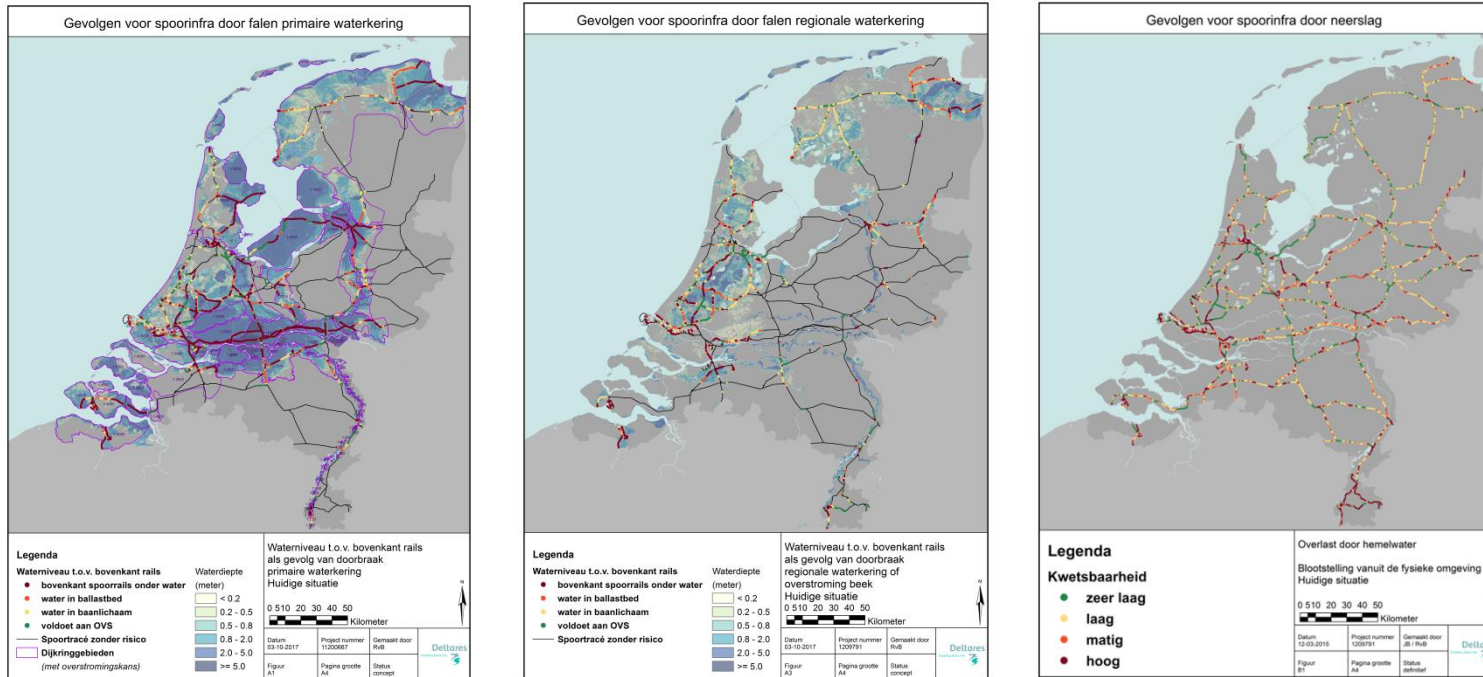
InnovA58 – client value



- Provide Adaptation Strategies (i.e. another way of building resilience instead of worst case approach) for high risk threats
 - Comparison with Federal Highway Administration tools and methods
- Collaborative approach with non-road related stakeholders e.g. municipalities, waterboards, nature organisations leading to social acceptance
- Alternative (and flexibel) solutions to increase climate resilience for regular over-design measures
- Method to include climate change into actual projects

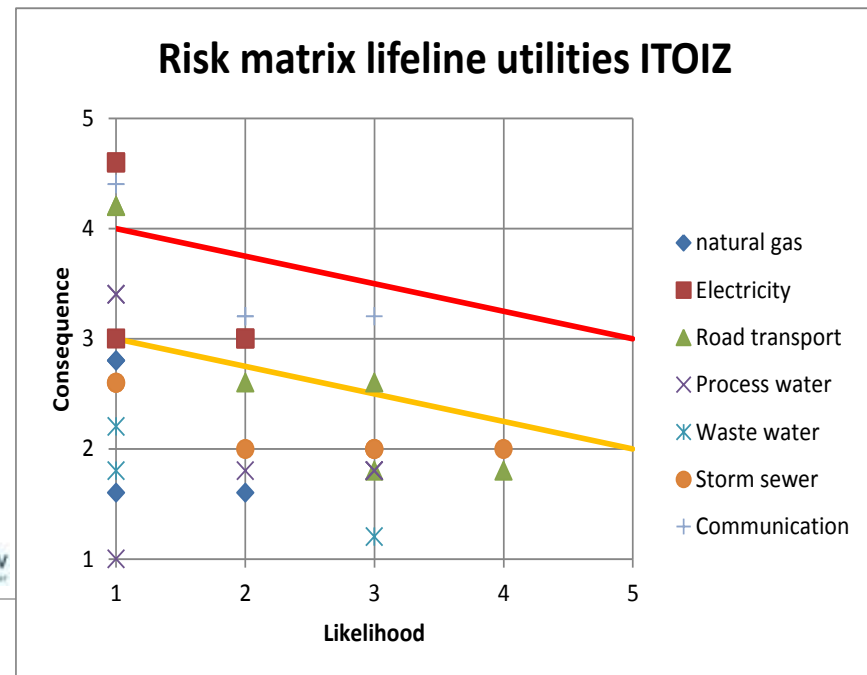
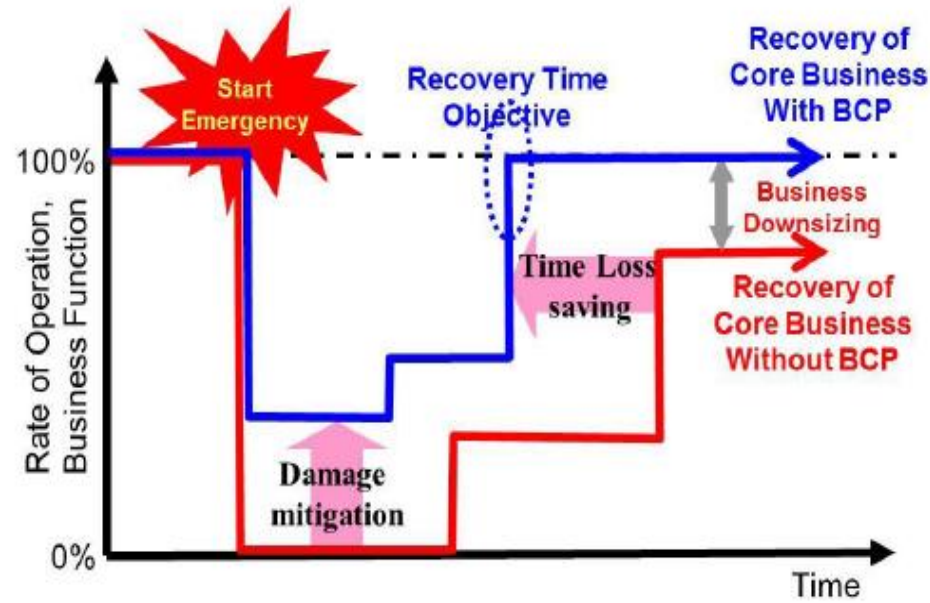
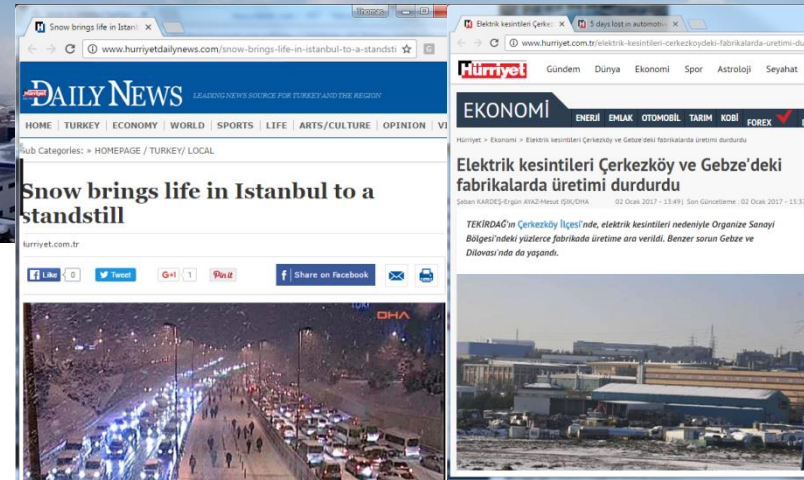
Blue Areas, Netherlands - client value

Vulnerability Assessment of current assets

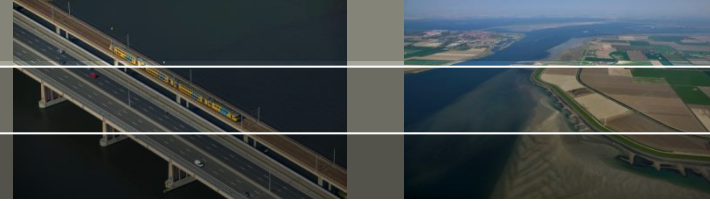


- Discussion with National government about acceptable risk levels for flooding
- Internal process to open discussion about effects of climate change for railways
- Technical process to evaluate and mitigate pluvial flooding locations

Tuzla – Istanbul – Business continuity planning



Tuzla, Turkey – client value



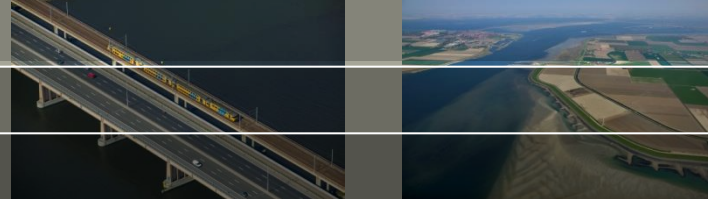
Results of the project:

- Lifeline Utility risk assessment for natural hazards
 - 7 top risk scenarios
- Business Continuity Plan
 - Plan that addresses measures to increase resilience of the industrialized zone

Value for the client

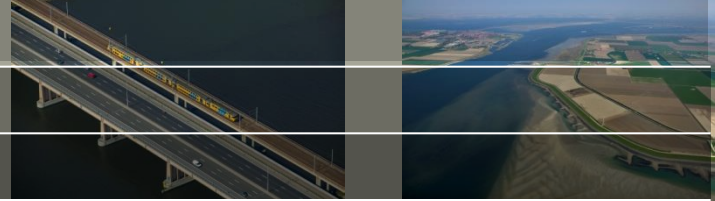
- Increased competitiveness for industrial zone management
- First example of a BCP for an industrialized zone in Turkey
 - Methodology established
 - To be used for other industrialized zones in Turkey and the world

Conclusions



- Method is widely adaptable for various
 - Climates
 - Hazards
 - Types of infrastructure
 - Available input data
- Results can be used for various reasons
 - Increase climate resilience
 - Better understanding of climate vulnerability
 - Prioritize action list & regions
 - Earmarking of funds
 - Secure (development) funding
 - Start discussion on responsibilities between organisations

Questions and discussion



Thank you for your attention

More Information

For info or further questions on this seminar and the activities of the JASPERS Networking Platform, please contact the JASPERS Networking and Competence Centre at the following email:

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