Third workshop on

Climate Change Adaptation in the Transport Sector

Experience from Project Preparation and Network Management

7th of April 2022 – Online

Session 2

Preparing climate change resilient transport investments

- **JASPERS, Introduction and some key considerations related to climate resilience during preparatory studies**

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- **Best Practice Case Studies**

Climate Change Vulnerabilities in Transport

Relevant climate hazards

Relevant hazards for transport	
Extreme temperature increase (including heat waves)	Changes in the frequency and intensity of extreme temperatures periods (both maximum and minimum) and heat waves
Cold spells	Prolonged periods of extremely cold temperatures
Change in average rainfall	Trends over time of either more or less precipitation (rain, snow, hail, etc.)
Change in extreme rainfall	Changes in the frequency and intensity of periods of intense precipitation
Snow	Changes in the frequency / intensity of periods of intense snow precipitation
Fog	Changes in the frequency and intensity of periods of intense fog
Maximum wind speed	Increases in the maximum force of gusts of wind
Freeze-thaw cycle	Repeated freezing and thawing may cause stress damage to materials/structures
Flooding (coastal/fluvial)	Flooding from the sea or from rivers
Soil erosion	The process of removal and transport of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, winds and underground water
Ground instability/ landslides/ avalanche	Ground instability: movement of the ground. Landslide: A mass of material that has slipped downhill by gravity, often assisted by water when the material is saturated. Avalanche: a rapid flow of snow down a sloping surface
Wild fires	Unwanted, unplanned and damaging fires such as forest fires and fires of shrub and grasslands

Climate Change Vulnerabilities in Transport

Understanding current & future exposure

- How is your project currently exposed to climate change? And how is it going to be in future?
- Availability of national platforms with climate change scenarios dissemination functions for a diversified user community and sectors
- Never underestimate the value of local/ historical/ anecdotal evidence (incl. incident data from transport operators)

Climate Change Vulnerabilities in Transport

How does climate impact transport systems? - Sensitivity

	Examples of possible impacts
Heavy precipitation	• damage to road assets (pavements, earthworks, structures, drainage systems etc.); • increased runoff to / from adjacent land causing flooding; • inundation from adjacent watercourses; • increased slope instability and landslides; • increased scour impact on road bridges (both abutments and intermediate supports); • ….
Extreme temperatures (heatwaves)	• damage to road pavement (e.g. softening, cracking, rutting, sweating, blown-ups etc.); • problems with bridges (stability, thermal expansion at bridge joints etc.); • track buckling; • increased risk of fires; • rolling stock overheating/failure; • increased needs for cooling (passenger/freight); • ….
Cold spells	• damage to pavement surface and equipment; • negative thermal expansion at bridges; • increased safety risks to users and operators; • traffic disturbance/congestion; • …

Climate Change in the Project Cycle

Climate resilience at all stages of project cycle

STRATEGY / PLAN → FEASIBILITY → DESIGN → PROCURE / BUILD → OPERATE / MAINTAIN → DECOMMISSION

Climate Change Resilience

Planning
Consider vulnerabilities of different solutions including location, maximize cost-effectiveness

Option Analysis
Incorporate CC Adaptation considerations and costs

Design
Long life of assets – design standards and future climate conditions

Procurement
Yellow FIDIC or alternative technical solutions – ensure the designed climate resilience is preserved

Operation
Monitoring and analysis of climate impacts as input into operations & management
User response systems

Let's look at some examples …

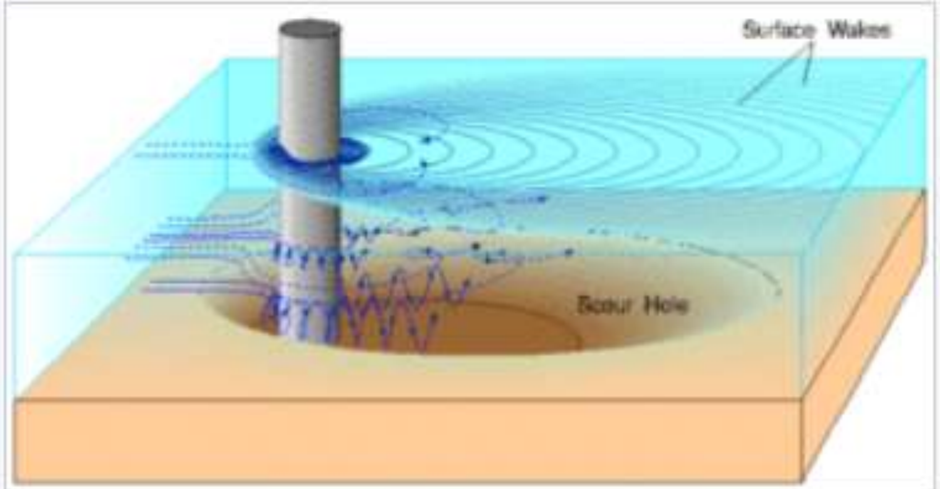
Case studies: Climate Change Vulnerabilities in Transport

Understanding climate change vulnerabilities

- ✓ What is the underlying climate hazard?
- ✓ What is its impact in this case?
- ✓ What adaptation measures could be adopted during:
  - Planning & preparation?
  - Design stages?
  - Procurement and construction?
  - Operation & maintenance period?

Case studies: Climate Change Vulnerabilities in Transport

Reflecting on related adaptation measures analysis



A diagram showing how scour holes are formed

- ✓ Flood maps – considerations of climate change scenarios
  - Prepared by other institutions
- ✓ Ideally hydraulic modelling for climate different scenarios
- ✓ Avoiding intermediate bridge supports or if they cannot be avoided protect them adequately
  - Options analysis of different options considering CAPEX & OPEX costs and other criteria
  - Possible tools: MCA, Simplified CBA etc.
- ✓ Higher bridge clearance above the water level
  - Revision of design standards
  - Justifications to go beyond design standards

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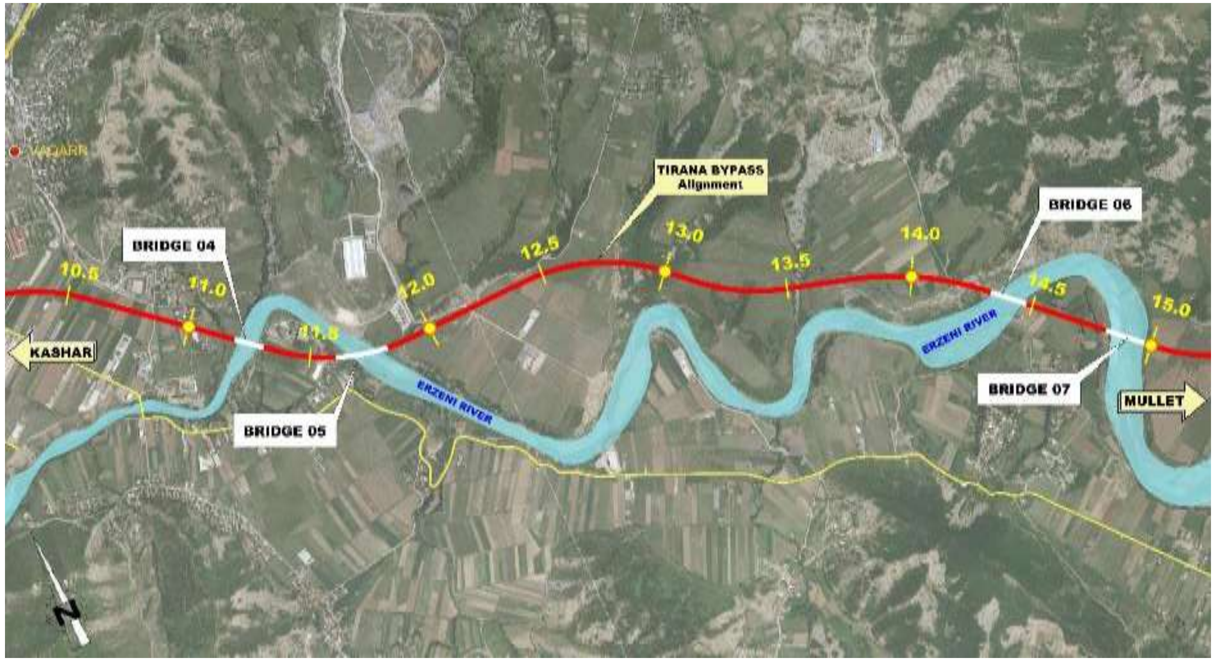
Project example

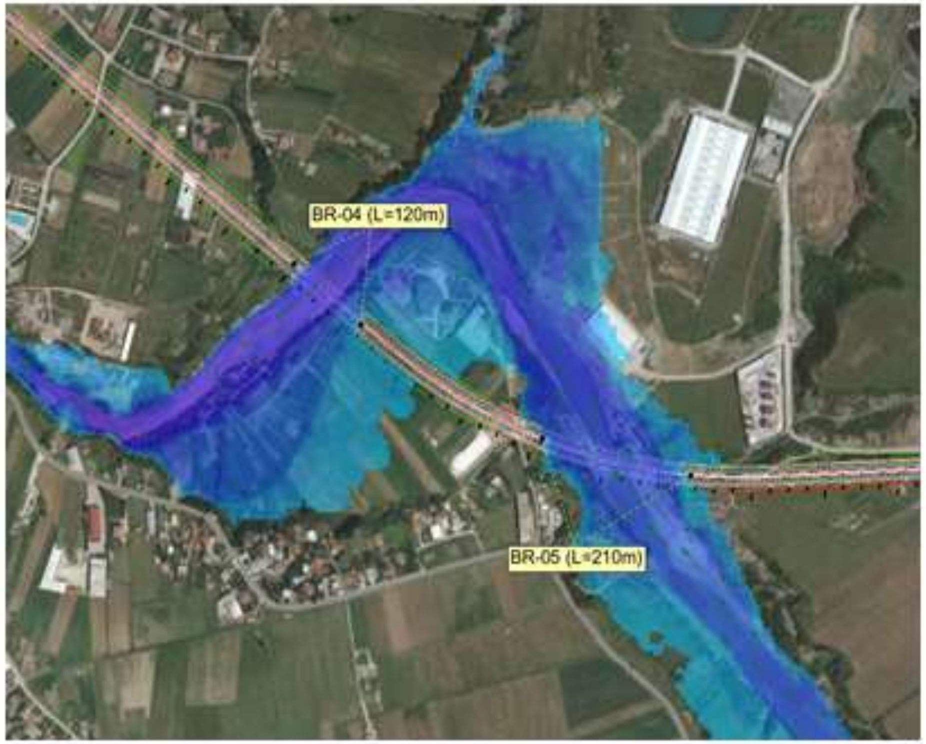


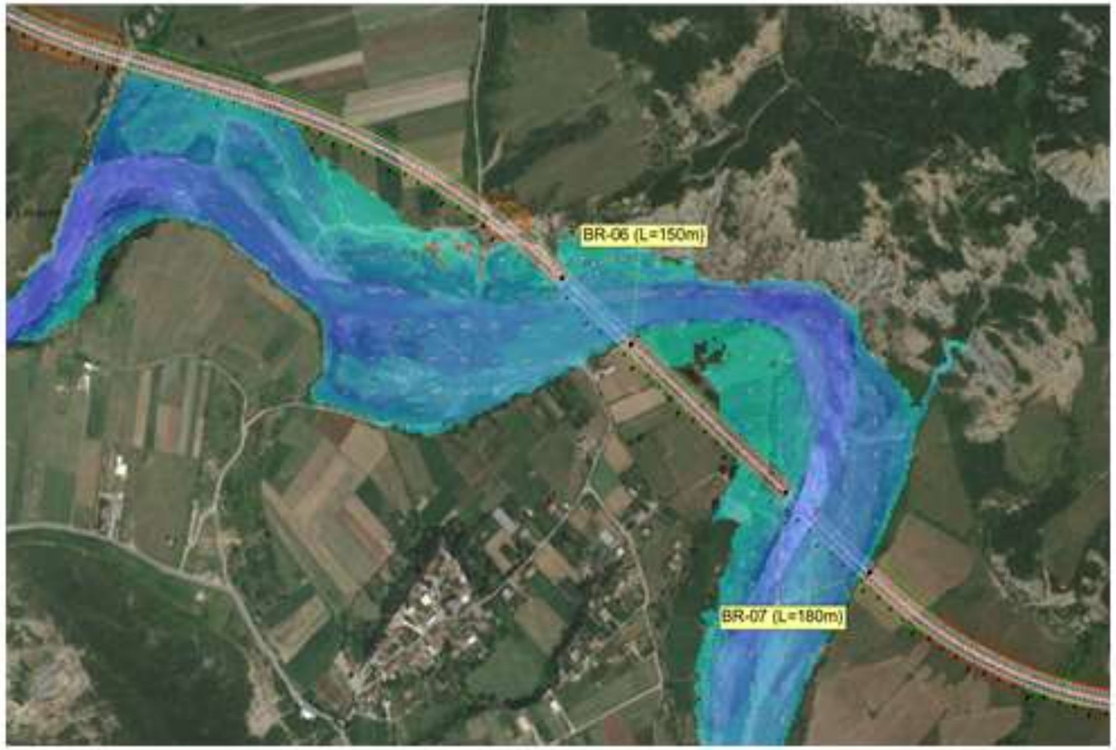
Source: WYG - IPF 5 Consortium

- ✓ City Bypass project
- ✓ Alignment located in the flood plain of a torrential river and its banks incl. four direct crossings of the river
- ✓ High seasonal fluctuation of the river flows (short duration of very high and above average river flows)
- ✓ Scour risk at intermediate bridge supports identified
- ✓ Locations of possibly instable river banks identified too
- ✓ JASPERS recommended a simplified analysis of various bridge spans to see whether it would be possible to reduce number of intermediate supports

Analysis of risks

Figure 2.1 Hydraulic modelling of the four (4) Erzeni river bridges





Source: WYG - IPF 5 Consortium

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Identification and comparison of feasible adaptation measures

Figure 1.4 Longitudinal section of Alternative 'A' for bridge 05 (7X30m)

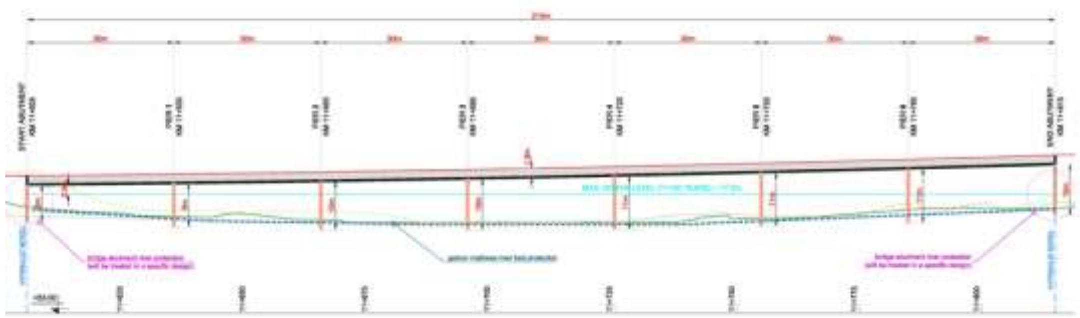


Figure 1.5 Longitudinal section of Alternative 'B' for bridge 05 (5X40m)

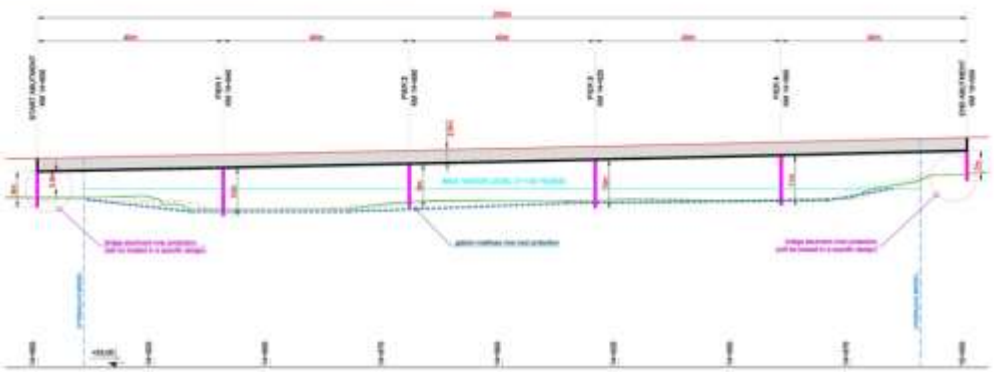
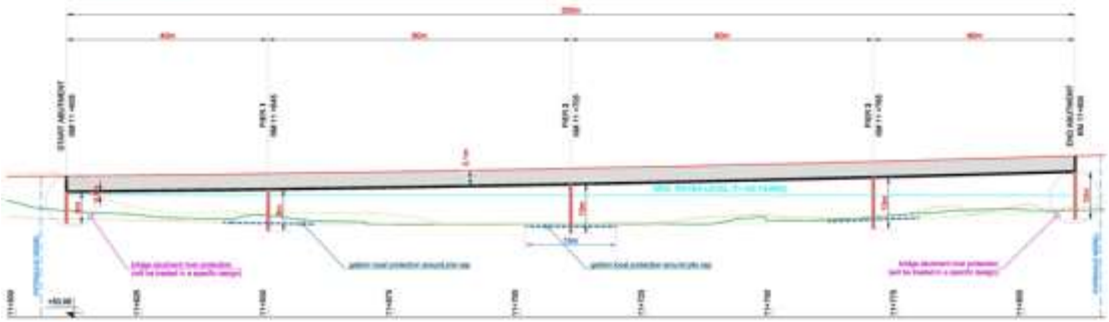


Figure 1.6 Longitudinal section of Alternative 'C' for bridge 05 (40+60+60+40m)



Source: WYG - IPF 5 Consortium

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Identification and comparison of feasible adaptation measures

Table 1 Examined alternatives

Alternative	max. span length	Structural system
Alternative 'A' (Basic Design)	30m	Prefabricated, simply supported prestressed beam girders
Alternative 'B'	40m	Prefabricated, simply supported prestressed beam girders
Alternative 'C'	60m	In-situ constructed, continuous prestressed box girder

Source: WYG - IPF 5 Consortium

Table 9: Maintenance cost of alternative bridge designs (Erzeni river)

Bridge Alternative	Total Length (m)*	Construction Cost (€)	Main Components of the Bridge	Life Cycle (Year)	Percentage (%) of Construction cost / component	Construction cost (€) / component	Annual Maintenance cost in (%) in relation to the construction cost***	Weights (indicative)	Indicative Maintenance cost (€)****	Indicative Total Maintenance cost (€)	Indicative Total Construction & Maintenance cost (€)
Alt. 'A' 30 m precast beam girders	660	17.424.000	Piers, Abutments, Foundation	100	50	8.712.000	0,50	1,80	7.840.800	14.866.157	32.290.157
			Superstructure	70	35	5.227.200	0,80	1,80	5.269.018		
			Facilities **	20	15	3.484.800	1,40	1,80	1.756.339		
Alt. 'B' 40 m precast beam girders	680	21.542.400	Piers, Abutments, Foundation	100	50	10.771.200	0,50	1,30	7.001.280	13.274.427	34.816.827
			Superstructure	70	30	6.462.720	0,80	1,30	4.704.860		
			Facilities **	20	20	4.308.480	1,40	1,30	1.568.287		
Alt. 'C' 50/60 m box girder	660	26.136.000	Piers, Abutments, Foundation	100	55	13.068.000	0,50	1,00	6.534.000	12.388.464	38.524.464
			Superstructure	70	27,5	7.840.800	0,80	1,00	4.390.848		
			Facilities **	20	17,5	5.227.200	1,40	1,00	1.463.616		

European Commission

European Investment Bank
The EU bank

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The simplified analysis in a nutshell:

- ✓ The comparison of the alternative bridge solutions considered the following aspects:
  - Hydraulic considerations
  - Construction method
  - Construction cost
  - O&M costs
  - Environmental??

- ✓ Scouring and erosion considered based on peak flows at the bridge locations with a return period of 200 years;
- ✓ Results showed that importance of different span numbers and lengths is lower than selection of the right type of intermediate supports (choosing a double column pier configuration over a single column solution with bigger diameter)
- ✓ Constructability and costs considered very important locally
- ✓ 30m span with double columns recommended with protective measures (gabion mattress etc.)

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Key takeaways:

As a Beneficiary/ Project Owner always:

- ✓ Ensure your Design Consultant performs a reliable and robust CC VRA tailored to your project based on reliable and up-to-date data (don't forget to include it in the scope of work in their ToR!);

- ✓ Ensure the key CC risks are identified;
- ✓ Ask the Consultant to propose a range of suitable adaptation measures for the key risks;
- ✓ Oversee that the adaptation measures are adequately compared using a relevant set of criteria and an adequate measure is selected (a sound but pragmatic engineering approach is required);
- ✓ Ensure the selected measures are properly incorporated into the Project Design during the upcoming preparatory/ procurement/ construction phases;

- ✓ Mainstream this CC VRA approach and process into all your projects;
- ✓ Don't be afraid of the CC VRA! Be pro-active! Insist and ask questions!

Best Practice Case Studies

Preparing climate change resilient transport investments

- Climate change resilience as a key pillar of EIB CBR & Project examples

  Birgitte Keulen – Mobility Department Climate Advisor, EIB

- Introducing climate change resilience in the transport sector, railway project experience

  Elisa Di Palma - Ministero delle infrastrutture e della mobilità sostenibili, Italy

- Integrating climate change resilience in design standards

  Markus Lundkvist - Trafikverket, Sweden

- Copernicus Climate Change Service: Sectoral Information System Supporting infrastructure, transport and associated standards

  Jorge Paz Jimenez - Fundación Tecnalia

More Information

For info or further questions on this webinar please contact the JASPERS Networking Platform team:

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