CLIMATE CHANGE IN MAJOR INFRASTRUCTURE PROJECTS

CASE STUDY: Project of Transport connection of separate territory of the Republic of Croatia/EU – Pelješac bridge with connecting roads

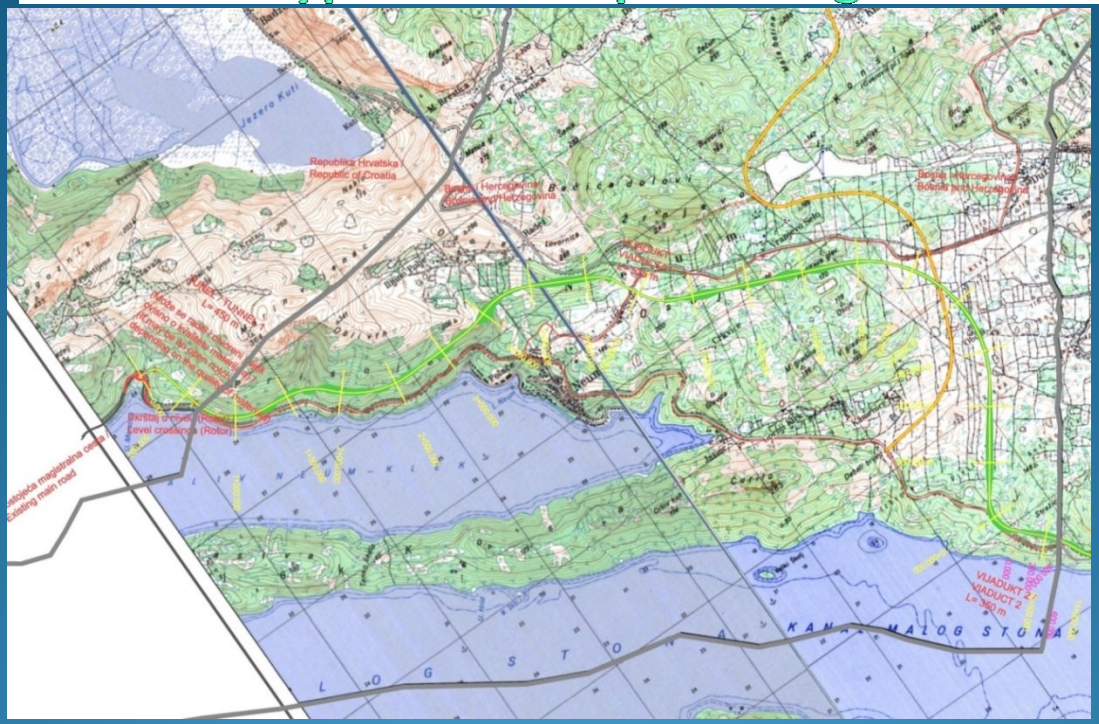
PROBLEM WE ARE TRYING TO RESOLVE

The Republic of Dubrovnik was a maritime republic situated in the city of Dubrovnik area Ragusa in Italian and Latin) in Dalmatia (today the southernmost Croatia).

It existed from 1358 to 1808.

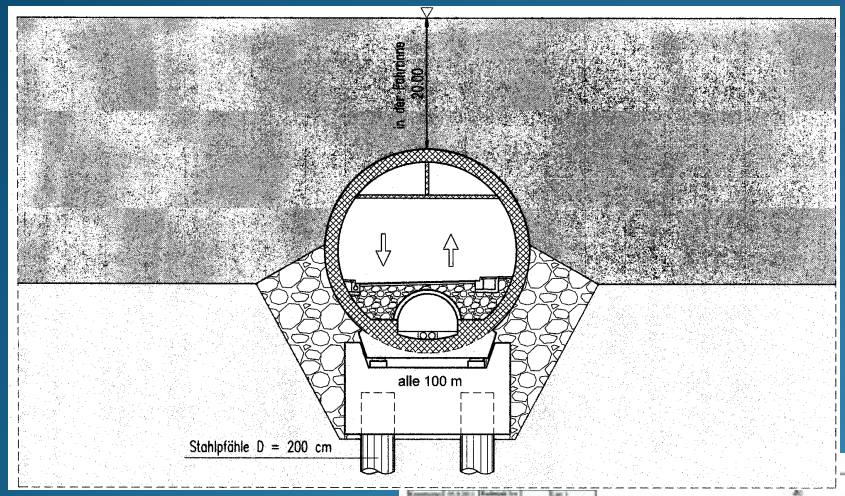
With the 1699 peace agreement, the Republic of Ragusa ceded two parts of its coast to the Ottoman Empire in order to disable the Republic of Venice attacks from land. One of them, the north-western land border with the small town of Neum, is today the only exit of the Republic of Bosnia and Herzegovina (BiH) to the Adriatic Sea.

RELEVANT OPTIONS ANALYSED IN PFS / FS:
Neum bypass with special legal status

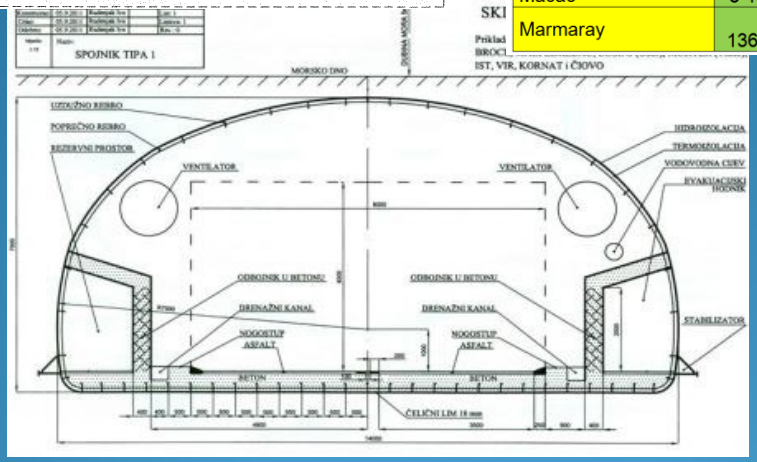


- Dividing coastal part of BiH from hinterland
- To avoid traffic jams at border control points, it should be exterritorial (EU territory). Otherwise, GHG emission is much higher compared with bridge option.
- Placed near water supply area, with karst soil. Active earthquake zone.

RELEVANT OPTIONS ANALYSED IN PFS / FS:
Immersed tunnel at bridge position



Project	Length (m)	Sea depth (m)	Price (EUR)	Unit price (EUR/m)	Year of completion	Type
Aktio-Preveza	1 570		90 000 000	57 325		road
Fehmarnbelt	18 000	45	5 500 000 000	305 556		road - railway
Oresund-tunnel	3 520	22	532 000 000	151 136	1994	road - railway
Hampton Road	2 000		3 000 000 000	1 500 000		road
Louis-Hippolyte Lafontaine	1 391		75 000 000	53 918	1963	road
63rd Street Tunnel	960		645 000 000	671 875		road
Sydney Harbour Tunnel	2 800	25	400 000 000	142 857	1992	road
Busan-Georje	3 200	40	600 000 000	187 500	2011	road
Fort McHenry Tunnel	2 400	33	600 000 000	250 000	1985	road
Limerick Tunnel	675		660 000 000	977 778		road
Hong Kong-Zhuhai-Macao	5 400	28	1 200 000 000	222 222	2017	road
Marmaray	13600	55	3 000 000 000	220 600	2013	railway



- Position of the tunnel in area with significant earthquake activity
- Tunnel tube should be resting on the pilots (as in the case of the bridge): costs?
- Relatively new type of transport infrastructure – hard to identify all climate risks

RELEVANT OPTIONS ANALYSED IN PFS / FS

Ferry harbours and ferry line at the position of the bridge

- Sea level rise - errosion of the coasts
- Ferry transport has a higher GHG emission per vehicle km than road transport

RELEVANT OPTIONS ANALYSED IN PFS / FS
Pelješac bridge with connecting roads

Change in maximum wind speed is a risk for this option

PREFERED AND FINAL OPTION :
PELJEŠAC BRIDGE WITH CONNECTING ROADS

The potential effects of Climate Change on the project has been evaluated in line with the methodology presented in the "Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient".

CLIMATE CHANGE ADAPTATION VUNERABILITY

The resilience of the project, separate for road and bridge, is assessed under a staged matrix analysis: firstly, examining sensitivity and vulnerability and secondly, examining probability and impact of primary and secondary climate change related events.

High vulnerability is identified for :

- Increase of extreme temperatures
- Change in extreme rainfall
- Change in maximum wind speed
- Storms
- Water availability

CLIMATE CHANGE EFFECTS ON THE PROJECT

- Risks have been assessed and adaptation measures have been defined.
- Most adaptation measures are integral part of the design and do not lead to additional costs.

ABOVE MENTIONED IS SHOWN AT FOLLOWING TABLES:

- Sensitivity to climate change effects of the Pelješac Bridge project
- Climate vulnerability for Pelješac Bridge
- Sensitivity to climate change effects on the access roads
- Climate vulnerability for the access roads
- Risk adaptation and costs

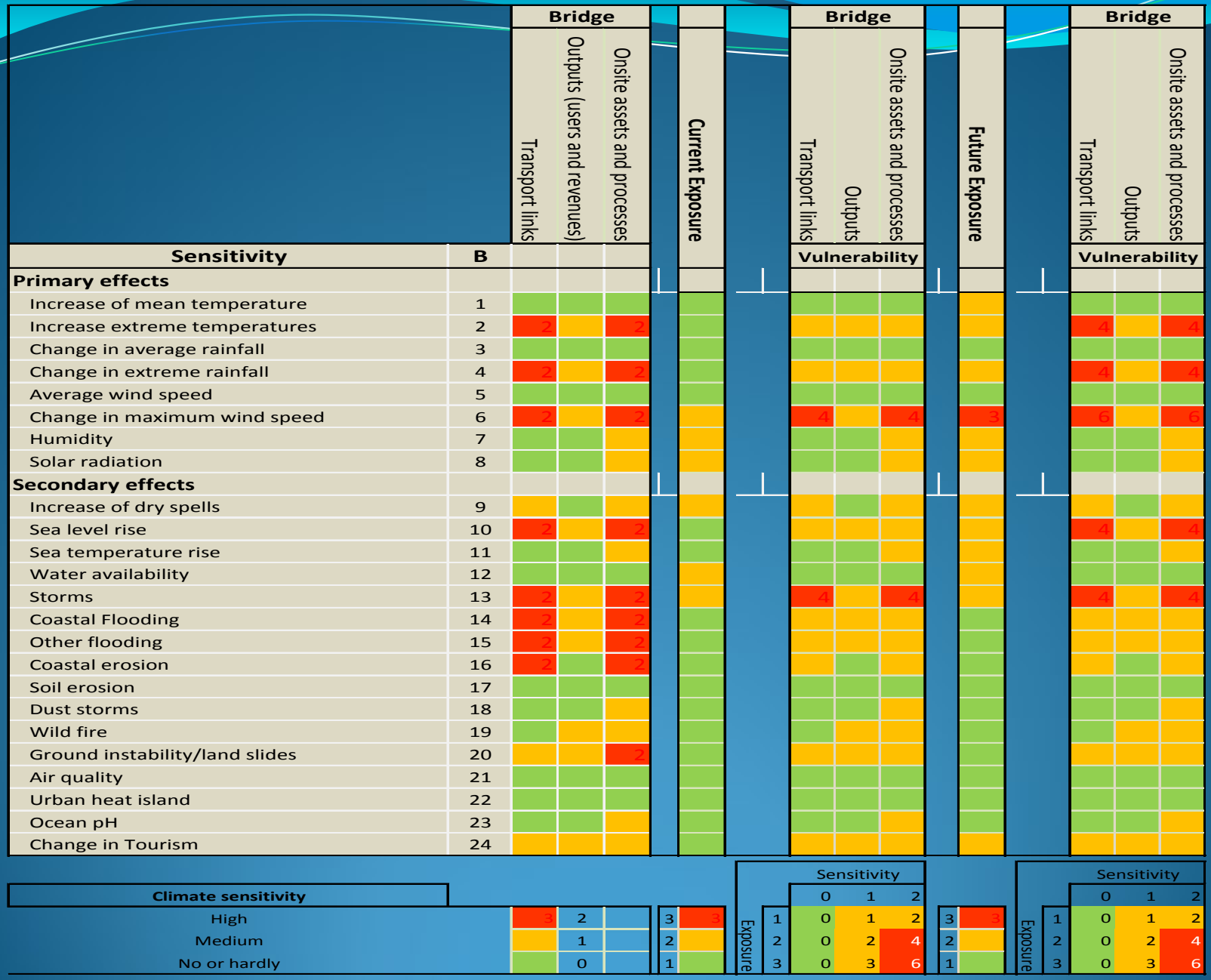
BRIDGE

Transport links

Outputs (users and revenues)

Onsite assets and processes

Sensitivity	B				
Primary effects					
Increase of mean temperature	1				Bridge structures are not sensitive to increase of mean temperature
Increase extreme temperatures	2	2		2	Additional expansion of structures, weakening of asphalt layers
Change in average rainfall	3				No sensitivity to average rainfall
Change in extreme rainfall	4	2		2	Impact on road drainage systems, insufficient drainage, water on road
Average wind speed	5				No impact
Change in maximum wind speed	6	2		2	Sensitivity of structures to extreme wind. Impact on traffic safety and flow. Potential closure of link.
Humidity	7				Potential impact on mechanical and electrical assets. Corrosion.
Solar radiation	8				Increased solar radiation may affect all exposed assets through increased wear.
Secondary effects					
Increase of dry spells	9				May increase the risk of surface smear and related safety at first rains.
Sea level rise	10	2		2	Impact on all structures in low laying areas; continuous non-useability
Sea temperature rise	11				Potential impact on bridge structures
Water availability	12				None
Storms	13	2		2	Covered by Extreme rainfall, Increase sensitivity for lightning strikes
Coastal Flooding	14	2		2	Impact on all structures in low laying areas; temporary non-useability
Other flooding	15	2		2	Impact on all structures in low laying areas; short term non-useability
Coastal erosion	16	2		2	Impact on all structures near the coast line
Soil erosion	17				No impact
Dust storms	18				Potential impact on mechanical and electrical assets and road safety.
Wild fire	19				Impact on road safety, reachability.
Ground instability/land slides	20			2	Impacts on road stability and road safety.
Air quality	21				No impact
Urban heat island	22				May impact on increase of extreme temparatures and storms (See 2 and 13)
Ocean pH	23				Increased acidification may impact on structures in contact with sea water. Increased corosion
Change in Tourism	24				Impact on traffic volumes and toll incomes.


Bridge
Transport links
Outputs (users and revenues)
Onsite assets and processes
Current Exposure
Bridge
Transport links
Outputs
Onsite assets and processes
Future Exposure
Bridge
Transport links
Outputs
Onsite assets and processes
Sensitivity
B
Vulnerability
Vulnerability
Primary effects
Increase of mean temperature 1
Increase extreme temperatures 2
Change in average rainfall 3
Change in extreme rainfall 4
Average wind speed 5
Change in maximum wind speed 6
Humidity 7
Solar radiation 8
Secondary effects
Increase of dry spells 9
Sea level rise 10
Sea temperature rise 11
Water availability 12
Storms 13
Coastal Flooding 14
Other flooding 15
Coastal erosion 16
Soil erosion 17
Dust storms 18
Wild fire 19
Ground instability/land slides 20
Air quality 21
Urban heat island 22
Ocean pH 23
Change in Tourism 24
Climate sensitivity
High
Medium
No or hardly
Sensitivity
Exposure
Sensitivity
Exposure

		Roads		
		Transport links		
		Outputs (users and revenues)		
		Onsite assets and processes		
Sensitivity	**R**			
Primary effects				
Increase of mean temperature	1			No impact on roads and road structures
Increase extreme temperatures	2	2	2	Weakening of asphalt stuctures, rutting.
Change in average rainfall	3			No sensitivity to average rainfall
Change in extreme rainfall	4	2	2	Impact on drainage systems. Stability of slopes and embankments.
Average wind speed	5			No impact
Change in maximum wind speed	6		2	Sensitivity of structures to extreme wind. Impact on traffic safety and flow. Potential closure of link.
Secondary effects				
Humidity	7			Potential impact on mechanical and electrical assets. Corrosion.
Solar radiation	8			Increased solar radiation may affect all exposed assets through increased wear.
Increase of dry spells	9			May increase the risk of surface smear and related safety at first rains.
Sea level rise	10	2	2	Impact on all structures in low laying areas; continuous non-useability
Sea temperature rise	11	2	2	Impact on road infrastructure in low laying areas
Water availability	12	2	2	Sensitivity in particular for firefighting in tunnels
Storms	13	2	2	Lighting on metal structures, electrical structures, flooding of tunnels, slope instability.
Coastal Flooding	14	2	2	Impact on all structures in low laying areas; temporary non-useability
Other flooding	15	2	2	Impact on all structures in low laying areas; short term non-useability
Coastal erosion	16	2	2	Impact on all structures near the coast line
Soil erosion	17			No impact
Dust storms	18			Potential impact on mechanical and electrical assets and road safety.
Wild fire	19			Impact on road safety, reachability.
Ground instability/land slides	20		2	Impacts on road stability and road safety.
Air quality	21			No impact
Urban heat island	22			May impact on increase of extreme temparatures and storms (See 2 and 13)
Ocean pH	23			Increased acidification may impact on structures in contact with sea water
Change in Tourism	24			Impact on traffic volumes

		Roads				Roads				Roads		
		Transport links	Outputs (users and revenues)	Onsite assets and processes	Current Exposure	Transport links	Outputs	Onsite assets and processes	Future Exposure	Transport links	Outputs	Onsite assets and processes
Sensitivity	**R**					**Vulnerability**				**Vulnerability**		
Primary effects												
Increase of mean temperature	1											
Increase extreme temperatures	2	2		2						4		4
Change in average rainfall	3											
Change in extreme rainfall	4	2		2						4		4
Average wind speed	5											
Change in maximum wind speed	6			2				4				4
Humidity	7											
Solar radiation	8											
Secondary effects												
Increase of dry spells	9											
Sea level rise	10	2	2	2								
Sea temperature rise	11	2		2								
Water availability	12	2		2		4		4		4		4
Storms	13	2		2		4		4		4		4
Coastal Flooding	14	2		2								
Other flooding	15	2		2								
Coastal erosion	16	2		2								
Soil erosion	17											
Dust storms	18											
Wild fire	19											
Ground instability/land slides	20			2				4				4
Air quality	21											
Urban heat island	22											
Ocean pH	23											
Change in Tourism	24											

Climate sensitivity			
High	3	2	
Medium		1	
No or hardly		0	

	3	3		
	2			
	1			

		Sensitivity		
		0	1	2
Exposure	1	0	1	2
	2	0	2	4
	3	0	3	6

	3	3		
	2			
	1			

		Sensitivity		
		0	1	2
Exposure	1	0	1	2
	2	0	2	4
	3	0	3	6

RISK ASSESSMENT AND ADAPTATION MEASURES

Risk	Adaptation	Cost
Increase of extreme temperatures		
Deterioration of asphalt layers due to increase of extreme temperatures	Use of appropriate asphalt composition.	Design measure, no additional costs.
Expansion of fixed structures due to extreme temperatures	Design of expansion joints and bearings to allow for increased temperatures	Design measure, no additional costs.
Change in extreme rainfall		
Instability of abutments, fills, road banks and slopes	Detailed route assessment of route and geological conditions and design of appropriate measures by stabilizing and water evacuation.	Design measure, no additional costs. Monitoring/control that protection measures are appropriate.
Insufficient water evacuation / drainage of road surfaces	Design of water evacuation measures taking into account larger rain intensities.	Design above usual standards for drainage. Some additional costs for drainage measures.
Change in maximum wind speed		
Damage to structures, buildings, and road signage	Design to high wind speeds.	Occurrence of high wind speeds is usual design in coastal Croatia. No additional cost.
Impact on traffic safety	Design of wind protection measures where risk for traffic safety can occur. Bridge includes wind screens. Roads are not exposed	Based on occurrence of high windspeeds in the coastal zones wind screens at exposed sites are usual design measures.
Storms		
Water evacuation and drainage see above		
Lighting risk for structures, powerlines, communication and signaling	Usual earthing measures according to design norms.	No additional costs
Water availability		
Risk of reduced water availability during dry season. Potential water shortage for firefighting in tunnels	Construction of water reservoirs for two tunnels to ensure sufficient supply to hydrant system	Limited additional costs.

THANK YOU FOR YOUR ATTENTION !

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