



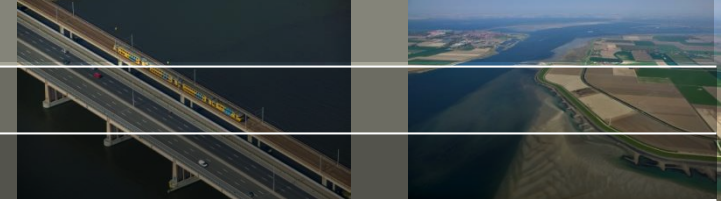
Feasibility Study Climate resilient road assets in Albania

a project financed by the World Bank

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Goal & scope of project



Inform the prioritisation of future climate and seismic resilient investments in primary road assets (in Albania)

Hazards

- Earthquakes
- Landslides
- Floods
 - Coastal
 - Fluvial

Approach – Risk analysis and action planning

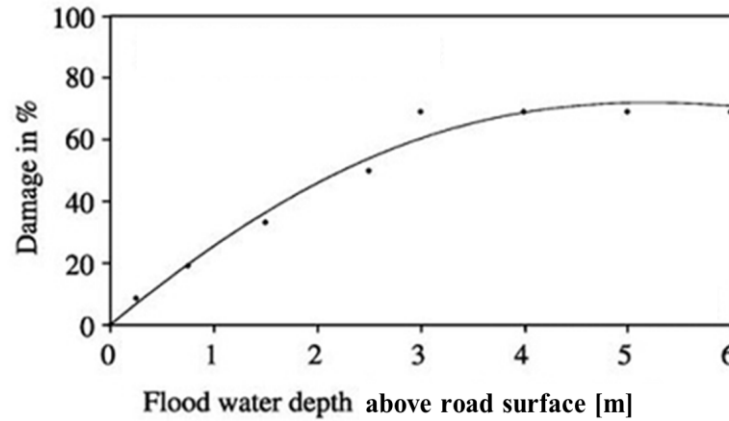
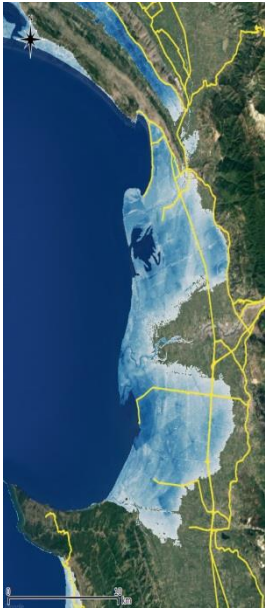
Risk analysis per hazard

- Hazard maps
- Risk analysis → Annual Expected Damages (AED)
 - Repair costs: Repairs to road assets
 - Corridor disruption: Economic damages from additional travel time and/or travel distance

Action planning

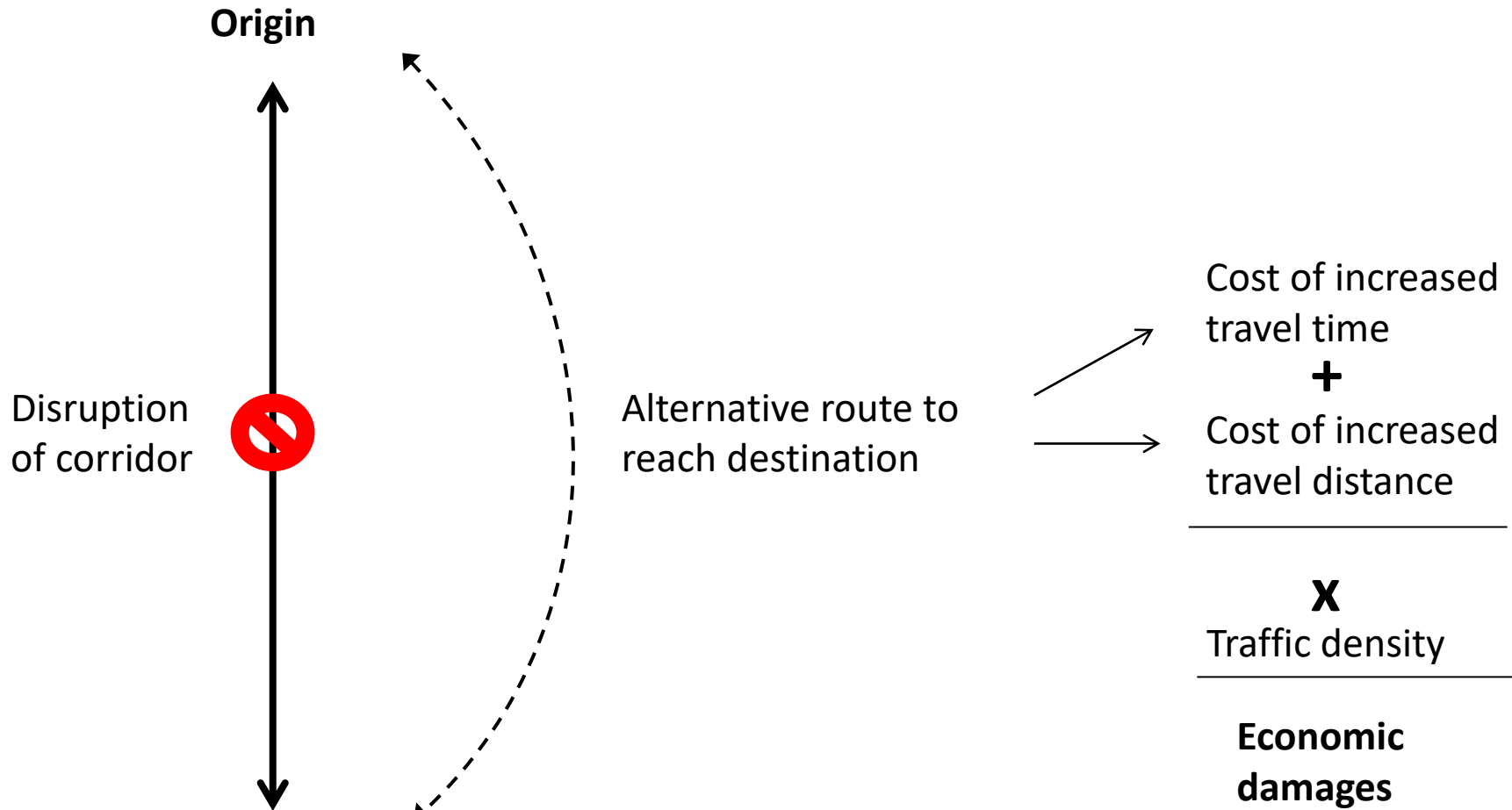
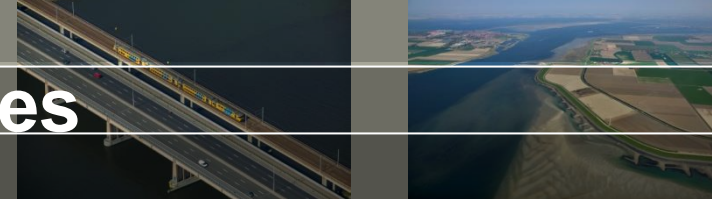
- Measures
- Cost benefit analysis (B/C ratio)
 - Cost = Cost of measures
 - Benefit = Reduction of AED
- Criticality

Approach – Repair costs



Damage to infrastructure (repair costs)

Approach – Economic damages



Risk map: Earthquakes

Used information:

- Earthquake Catalog – IGEWE Albania –
- Faults Database – (EDSF) - 2013.

Conclusion

- Only impact on bridges at 1:2,475 years return period
- Annual expected damages are diffuse and relatively small, in general less than € 500/year/km
- Not included in action planning

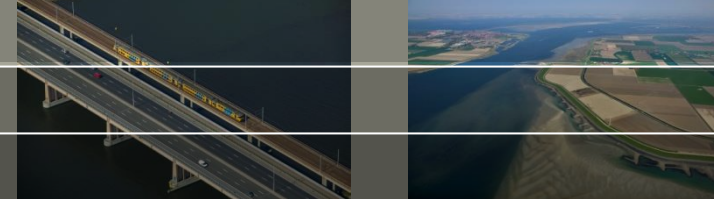


Risk assessment for floods, landslides and earthquakes

Annual Expected Damages	Floods	Land sl.	FQ	Total
01 Milot - Morine New	16,737	324,373	6,079	347,188
02 Q. Qele - Puke	13,396	112,808	14,194	140,398
03 Milot - Shkoder	1,540,190	90,040	177,787	1,808,017
04 Tirana - Durres	1,793,170	116,378	191,444	2,100,991
05 Durres - Fier	9,981,132	513,307	350,730	10,845,169
06 Tirana- Elbasan	3,004,926	456,556	127,413	3,588,895
07 Fier - Tepelene	1,252,073	105,858	61,559	1,419,491
08 Sarande - Greqi	40,927	39,710	5,553	86,189
09 Elbasan - Gramsh	717	26,243	27,484	54,444
10 Lushnje - Berat	254,003	93,458	42,334	389,796
11 Rogozhine - Elbasan	6,332	29,090	49,935	85,357
12 Shkoder - Hani - Hotit	190,376	97,336	31,355	319,066
13 Milot - Peshkopi	517,200	198,058	27,417	742,675
14 Vlore - Sarande	136,023	178,477	23,513	338,012
15 Pogradec - Korce	-	57,172	86,054	153,225

- Annual Expected Damages per hazard and corridor
- Earthquakes excluded from action planning due to dispersed impact and limited AED/km





What defines criticality?

- Strategic function (evacuation, national corridor, international connection)
- Services specific important economic functions
- Servicing otherwise difficult to reach destinations

How do we use the criticality in decision making

- Prioritise interventions (what, where) based on the order of importance for factors such as ,International corridor, Tourism,Industry,Agriculture etc.

Conclusion

- Corridors 4 and 5 are most critical → highest priority
- Corridors 2, 9 and 10 are least critical → lowest priority

Criticality

- Strategic function (evacuation, national corridor, international connection)
- Services specifically important for economic functions
- Servicing otherwise difficult to reach destinations

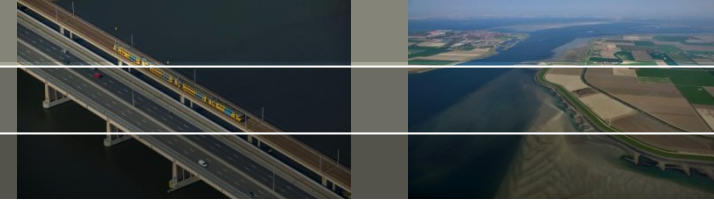
Criticality determined during workshop with local stakeholders.

Take into account, importance for :

- International connections
- Industry
- Harbour
- Tourism
- Evacuation

Conclusion

- Corridors 4 and 5 are most critical → highest priority
- Corridors 2, 9 and 10 are least critical → lowest priority



Risk assessment and criticality per corridor

Annual Expected Damages and criticality → Input for Action Plan

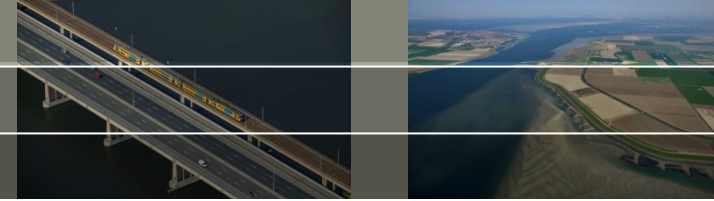
Corridor	Length (km)	Total	€/km	Criticality
01 Milot - Morine New	104	347,188	3,328	41.6
02 Qele - Puke	126	140,398	1,118	24.2
03 Milot - Shkoder	127	1,808,017	14,189	36.7
04 Tirana - Durres	32	2,100,991	65,058	53.4
05 Durres - Fier	152	10,845,169	71,289	51.7
06 Tirana- Elbasan	139	3,588,895	25,839	42.2
07 Fier - Tepelene	128	1,419,491	11,071	36.5
08 Sarande - Greqi	58	86,189	1,477	38.5
09 Elbasan - Gramsh	41	54,444	1,343	26.1
10 Lushnje - Gramsh	86	389,796	4,555	23.6
11 Rrogozhine - Elbasan	40	85,357	2,128	36.7
12 Shkoder - Hani - Hotit	125	319,066	2,562	40.0
13 Milot - Peshkopi	136	742,675	5,459	30.1
14 Vlore - Sarande	131	338,012	2,587	39.2
15 Pogradec - Korce	69	153,225	1,975	44.8

Hazards assessed for action plan

Hazards

- ~~Earthquakes~~
- Landslides
- Floods
 - ~~Coastal~~
 - Fluvial

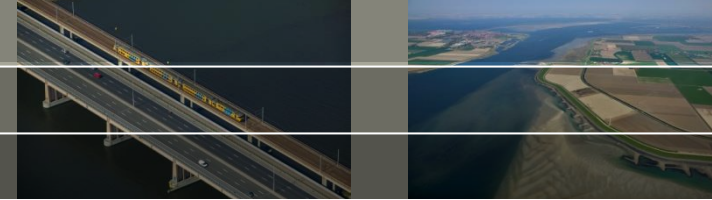
Landslides



The downward movement of a mass of rock, earth, or artificial fill on a slope, often induced (started) by prolonged or heavy rainfall.



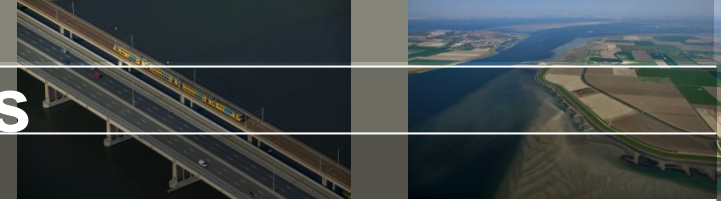
Landslide – Total risk



Annual damages from interruption of services and repair costs per corridor from landslides (€)

Landslides	Repair Costs (€)	Interruptions (€)	Total (€)
01 Milot - Morine New	286,714	37,659	324,373
02 Q. Qele - Puke	109,519	3,289	112,808
03 Milot - Shkoder	38,473	51,567	90,040
04 Tirana - Durres	44,776	71,602	116,378
05 Durres - Fier	150,035	363,272	513,307
06 Tirana- Elbasan	200,240	256,316	456,556
07 Fier - Tepelene	60,806	45,052	105,858
08 Sarande - Greqi	39,453	257	39,710
09 Elbasan - Gramsh	24,677	1,566	26,243
10 Lushnje - Berat	63,581	29,877	93,458
11 Rrogozhine - Elbasan	17,366	11,724	29,090
12 Shkoder - Hani - Hotit	76,293	21,043	97,336
13 Milot - Peshkopi	123,935	74,123	198,058
14 Vlore - Sarande	146,329	32,148	178,477
15 Pogradec - Korce	22,438	44,734	67,172

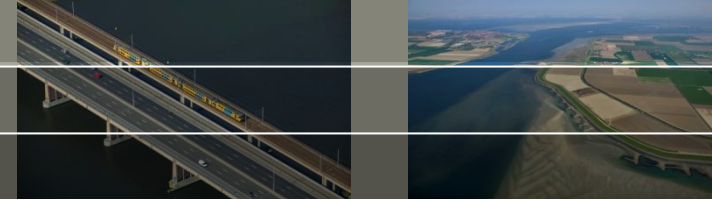
Landslides - Typical measures



- **Retaining structures e.g. retaining walls, gabion walls**
- **Stepped slope embankments**
- **Internal slope reinforcement e.g. rock bolts**
- **Drainage**
- **Reforestation**
- **(Improved) regular/ preventative maintenance**
- **Better response/ repair plan (i.e. shorter response times)**



Landslide - Measures



Proposed measures per corridor, based on:

- Vulnerability
- Terrain conditions

Engineering measures	Cost/10 m (€)	05 Durres - Fier		06 Tirana- Elbasan		13 Milot - Peshkopi		14 Vlore - Sarande	
		Length	Cost	Length	Cost	Length	Cost	Length	Cost
Road Edge failure Retaining Wall	11,000	100	110,000	-	-	7,000	7,700,000	10,000	11,000,000
Soft rock Retaining Wall	11,000	200	220,000	3,100	3,410,000	20,000	22,000,000	-	-
Stepped slope embankement	42,000	-	-	500	2,100,000	-	-	-	-
Slope protection	14,000	400	560,000	500	700,000	-	-	-	-
Hard rock Slope protection	121,000	450	5,445,000	100	1,210,000	200	2,420,000	-	-
TOTAL			6,335,000		7,420,000		32,120,000		11,000,000

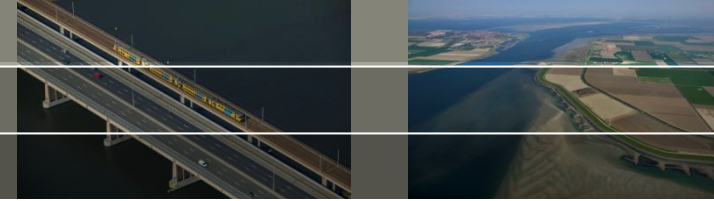
Landslides - Cost Benefit Analysis

Corridor	Investments	Benefits	B/C ratio
01 Milot - Morine New			
02 Q. Qele - Puke			
03 Milot - Shkoder			
04 Tirana - Durres			
05 Durres - Fier	6,335,000	6,699,804	1.1
06 Tirana- Elbasan	7,420,000	5,959,086	0.8
07 Fier - Tepelene			
08 Sarande - Greqi			
09 Elbasan - Gramsh			
10 Lushnje - Berat			
11 Rrogozhine - Elbasan			
12 Shkoder - Hani - Hotit			
13 Milot - Peshkopi	32,120,000	2,585,097	0.1
14 Vlore - Sarande	11,000,000	2,329,525	0.2
15 Pogradec - Korce			

Based on CBA:

- Assuming measures will reduce AED by 50 %, over 25 years at 4 % net discount rate as benefit, and a traffic growth of 4 %
- Corridors 5 and 6, positive decision on investments
- Corridors 13 and 14, negative decision on investments

Flooding - Description



Fluvial, or riverine flooding, occurs when excessive rainfall over an extended period of time causes a river to exceed (its capacity or) the capacity of a culvert or bridge.



Floods - Risks

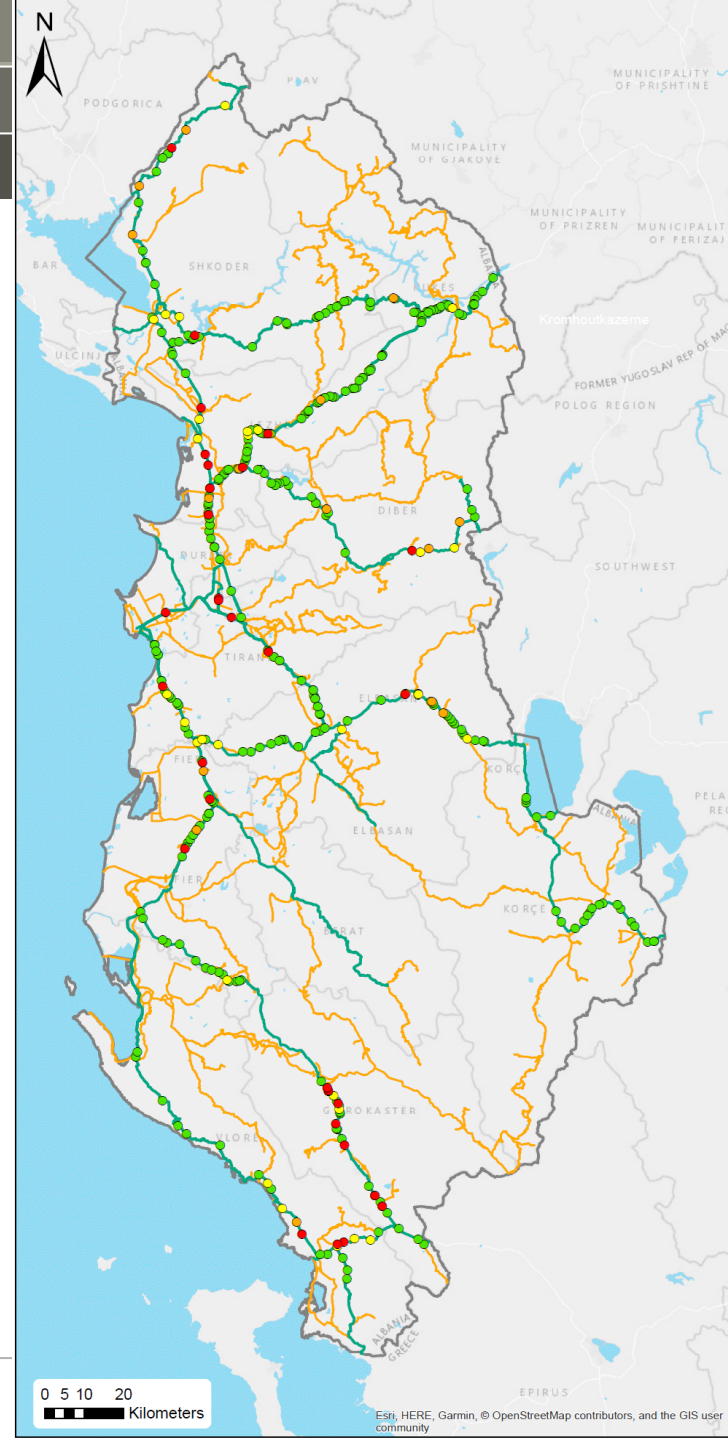
Vulnerability

Dots indicate culvert and bridge failures (High, Low)

Based on:

- Modelled discharges
- Design capacities

Intervention on 17 red locations (~ 20 %)



Del
Enabling Delta Life

SEEDC
Smart Environment
Engineering Design

Climate resili

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Albania and t
floods to brid
climate scen

Date:

Projectnr:
Mapcode:

Authors:

Legend

- Albania
- Primary
- Secondary

**Damages
bridges a**

Climate s

- No dan
- Small
- Mediu
- Large

0 5 10 20
Kilometers

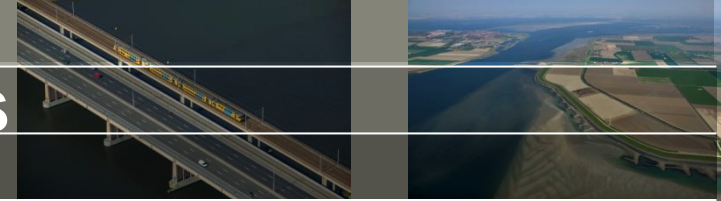
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Flooding rivers – Economic damages

Annual Expected Damages (AED) for floods

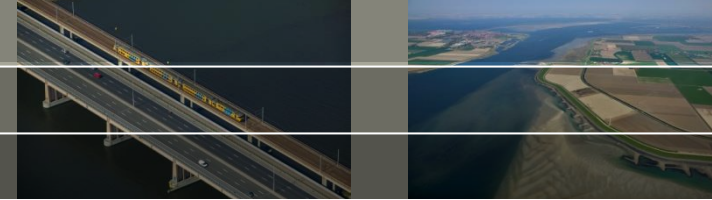
Annual Expected Damages	Length (km)	Interuption	Repairs	Total	€/km
		Sub-tot	Sub-tot		
01 Milot - Morine New	104	53,840	293,348	347,188	3,328
02 Q. Qele - Puke	126	9,105	131,294	140,398	1,118
03 Milot - Shkoder	127	1,354,587	453,430	1,808,017	14,189
04 Tirana - Durres	32	1,920,023	180,968	2,100,991	65,058
05 Durres - Fier	152	10,426,924	418,245	10,845,169	71,289
06 Tirana- Elbasan	139	3,241,456	347,439	3,588,895	25,839
07 Fier - Tepelene	128	1,100,059	319,431	1,419,491	11,071
08 Sarande - Greqi	58	2,133	84,056	86,189	1,477
09 Elbasan - Gramsh	41	2,804	51,639	54,444	1,343
10 Lushnje - Berat	86	262,826	126,969	389,796	4,555
11 Rrogozhine - Elbasan	40	37,618	47,740	85,357	2,128
12 Shkoder - Hani - Hotit	125	172,553	146,513	319,066	2,562
13 Milot - Peshkopi	136	558,937	183,738	742,675	5,459
14 Vlore - Sarande	131	151,425	186,587	338,012	2,587
15 Pogradec - Korce	69	83,671	69,554	153,225	2,222

Floods - Suggested measures



- **Increase capacity culverts**
- Reduce peak flow (retention ponds/reforestation)
- (Improved) regular/ preventative maintenance
- Erosion protection
- Better repair plan (i.e. shorter to reaction times)
- Build back better based on improved/ updated design criteria and performance standards

Floods - Measures



Bill of quantity for culvert replacement (0.75; 2.5; 16 or 50 m³/s)

Corridor	Q50	Q16	Q2.5	Q0.75	Q50	Q16	Q2.5	Q0.75	Investment (€)
01 Milot - Morine New	0	0	0	0	-	-	-	-	-
02 Q. Qele - Puke	1				75,000	-	-	-	75,000
03 Milot - Shkoder					-	-	-	-	-
04 Tirana - Durres					-	-	-	-	-
05 Durres - Fier		1	2		-	42,000	16,000	-	58,000
06 Tirana- Elbasan	1				75,000	-	-	-	75,000
07 Fier - Tepelene	4	1	2	0	300,000	42,000	16,000	-	358,000
08 Sarande - Greqi					-	-	-	-	-
09 Elbasan - Gramsh					-	-	-	-	-
10 Lushnje - Berat		1			-	42,000	-	-	42,000
11 Rrogozhine - Elbasan					-	-	-	-	-
12 Shkoder - Hani - Hotit		1			-	42,000	-	-	42,000
13 Milot - Peshkopi		1	1		-	42,000	8,000	-	50,000
14 Vlore - Sarande		1	1		-	42,000	8,000	-	50,000
15 Pogradec - Korce					-	-	-	-	-

Costs of culverts replacements per corridor

- Per capacity
- Total per corridor

Flooding – Cost Benefit Analysis of measures

B/C ratio: Repair costs only

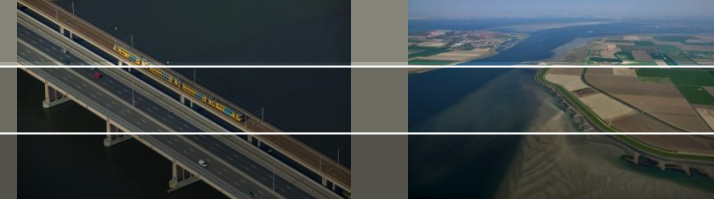
B/C ratio: Interruptions and repair costs

Corridor	Investment (€)	Benefits (€)	B/C ratio
01 Milot - Morine New	-	-	-
02 Qele - Puke	75,000	46,800	0.6
03 Milot - Shkoder	-	-	-
04 Tirana - Durres	-	-	-
05 Durres - Fier	58,000	1,079,520	19
06 Tirana- Elbasan	75,000	616,590	8
07 Fier - Tepelene	358,000	2,831,790	8
08 Sarande - Greqi	-	-	-
09 Elbasan - Gramsh	-	-	-
10 Lushnje - Gramsh	42,000	624,000	15
11 Rrogozhine - Elbasan	-	-	-
12 Shkoder - Hani - Hotit	42,000	621,270	15
13 Milot - Peshkopi	50,000	640,770	13
14 Vlore - Sarande	50,000	409,500	8
15 Pogradec - Korce	-	-	-

Corridor	Investment (€)	Benefits (€)	B/C ratio (Growth)
01 Milot - Morine New	-	0	-
02 Qele - Puke	75,000	106,729	1.4
03 Milot - Shkoder	-	-	-
04 Tirana - Durres	-	-	-
05 Durres - Fier	58,000	141,296,775	2,436
06 Tirana- Elbasan	75,000	27,429,674	366
07 Fier - Tepelene	358,000	21,242,387	59
08 Sarande - Greqi	-	-	-
09 Elbasan - Gramsh	-	-	-
10 Lushnje - Gramsh	42,000	6,273,880	149
11 Rrogozhine - Elbasan	-	-	-
12 Shkoder - Hani - Hotit	42,000	4,223,510	101
13 Milot - Peshkopi	50,000	10,532,861	211
14 Vlore - Sarande	50,000	3,196,637	64
15 Pogradec - Korce	-	-	-

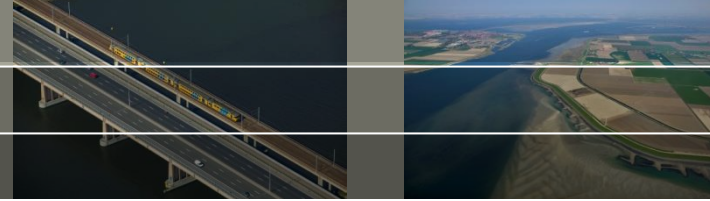
Measures are economically viable when B/C ratio > 1.0

Conclusions and Discussion



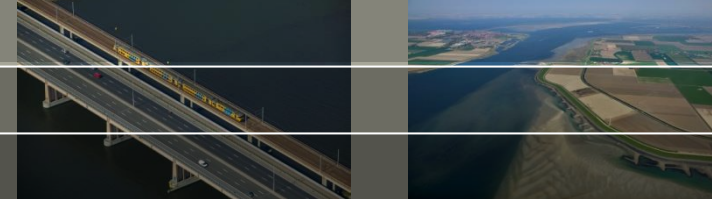
- Study presents first impressions, findings should be verified in the field
- Future studies would benefit from registration of events
- Little impact from earthquakes due to low probability
- Little impact from coastal floods to road assets due to little exposure
- **Landslide have significant impact but measures only economically feasible for corridors with high AED**
- **Floods have major impacts, replacements are generally economically feasible, but location of culverts should be verified, more detailed study required**
- Adequate maintenance for culverts is important for performance of the road network

Lessons learned 1



- Desktop studies based on global/ regional input data with coarse traffic data (corridor level) can produce useful and objective (strategic) results at a network level
 - Results are a first scan at network level
 - View input and results in this context
 - Strategic assessment, not possible to downscale
- Field validation is required for next steps (execution of action plan)
 - Are identified locations indeed vulnerable?
 - Does cost estimate of measure fit with location?
 - Update CBA if needed
- Difficult to find reliable input
 - Damage functions
 - Historical data (for validation)
 - Repair costs, downtimes, cost of measures per corridor

Lessons learned 2



- Local input very important
 - Local partners are vital (network, experience and 1st validation)
 - Interaction with local stakeholders (e.g. workshops)
 - *Q: How to get the right people to attend?*
- Project results can be used to improve Road Asset Management System (RAMS)
 - Registration/data collection of events may help improve future studies
- Implementation of results requires ‘local fit’
 - maturity level of local organization
 - create bottom up/ local support (e.g. via Emergency Management)
 - champions: requires capacity building