Climate and disaster resilient Transport Infrastructure

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Outline

• Transport Infrastructure Resilience - challenges and opportunities

• Activities in Western Balkan countries

• Disaster Risk Management and Transport infrastructure Activities in Serbia

• Guidelines for the Road Transport Network Vulnerability Assessment

• Discussion
RESILIENCE
Challenges and experiences around the world
The challenge: transport infrastructure is vulnerable to climate and disaster risks

<table>
<thead>
<tr>
<th>Infrastructure is built in highly hazard prone areas</th>
<th>Risk assessments are not properly used in planning</th>
<th>Policy and planning don’t address disaster and climate risks</th>
<th>Options needed for connectivity (redundancy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proper geotechnical studies are not carried out</td>
<td>Design codes and standards are not updated</td>
<td>Tools needed to address these vulnerabilities</td>
<td>Poor industry capacity</td>
</tr>
<tr>
<td>Lack of updated and easily accessible asset management system</td>
<td>Lack of funding and political will for resilience and maintenance</td>
<td>Infrastructure is poorly maintained</td>
<td>High upfront costs</td>
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<tr>
<td>Disaster recovery process and protocols are needed</td>
<td>Poor financial planning</td>
<td>Poor understanding of systems functioning in the aftermath of a disaster</td>
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</table>
The Opportunity: Apply a lifecycle approach to increase the resilience of infrastructure

- Life cycle approach is applied to highlight that infrastructure undergoes processes of growth, reorganization / development, deterioration / conservation, and destruction.
- Addressing resilience opportunities at various phases of the life cycle enables a reflective, stable, and systems oriented resilience capacity (socio-ecological resilience).
- The objective is to respond and evolve rather than stay static and vulnerable to threats of climate hazard-induced structural or systemic failure.
- Disaster risk financing techniques can help price the risk faced by lifeline-critical infrastructure (beyond normal maintenance) and allows for better financial planning that contributes to increasing the resilience of infrastructure.
Engeenering and design

- Innovative material’s design standards and specifications that enhance robustness and flexibility of infrastructure
- Conducting hazard assessment of project site to identify and reduce risks of and around infrastructure.
- Conducting infrastructure level vulnerability assessments to identify points of weakness and identify what modifications preventative measures and response mechanisms could be put in place to reduce the likelihood of failure or for ensuring safe failure.
Operation and Maintenance (example Mozambique)

- Inventorying and mapping of transport infrastructure assets using open and inter-operable technologies and improving institutional, financial and contractual arrangements for infrastructure maintenance.

- Integrating climate and disaster risk considerations in the prioritization of investments in new infrastructure, rehabilitation, and restoration.
Data & Technology (example Belize and Dominica)

- Roadways
- Bridges
- Earthwork
- Drainage
- Flood
- Landslide
- Social
- Economic
- Environmental
- MoPWP
- Community
World Bank growing portfolio in resilient transport

**Portfolio** *contains all the projects within the Resilient Transport CoP.*

**Project Commitment and Grant** *contains all projects within the Resilient Transport CoP.*
Western Balkan Countries
Activities in Western Balkan Countries

• Grant funded activities:

  • Albania (~300 K): under preparation

  • Bosnia and Herzegovina (~100 K): assess vulnerability and prioritize list of climate resilient related interventions for roads under the program

  • Serbia (~200K )

• Regional resilience operation covering all WB6 countries (1 million): to build on country specific activities and recommendations

• Integral part of all ongoing and planed lending activities in the client countries
DRM and transport resilience activities in Serbia
Natural Hazards (spatial plan 2010-20 and projections)

- Total damage caused by extreme climate and weather conditions, since 2000, exceeds 5 Billion EUR.

- More than 70% of losses are associated with drought and high temperatures.

- A major cause of significant losses were floods.

- The two most extreme climate and weather episodes were the drought in 2012 and the floods in 2014.

<table>
<thead>
<tr>
<th>Natural hazards</th>
<th>P [km²]</th>
<th>[%] of total P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismicity VIII–IX MCS</td>
<td>16 388.59</td>
<td>18.55</td>
</tr>
<tr>
<td>Seismicity IX–X MCS</td>
<td>1109.71</td>
<td>1.26</td>
</tr>
<tr>
<td>Excessive erosion</td>
<td>3320.80</td>
<td>3.76</td>
</tr>
<tr>
<td>Landslides</td>
<td>13 327.60</td>
<td>15.08</td>
</tr>
<tr>
<td>Drought</td>
<td>18 306.93</td>
<td>20.72</td>
</tr>
<tr>
<td>Floods</td>
<td>15 198.07</td>
<td>17.20</td>
</tr>
<tr>
<td>Wild fire</td>
<td>3154.95</td>
<td>3.57</td>
</tr>
<tr>
<td>Total area</td>
<td>50 659.87</td>
<td>57.33</td>
</tr>
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</table>
Floods 2014 (https://www.youtube.com/watch?v=cK1OBD1hLWk)

- Most severe flooding in 120 years.
- More than 1.6 million people affected (22% of the total population) in 38 municipalities.
- 57 lives lost and 32,000 families evacuated and displaced.

- The total effects of the disaster in 24 affected municipalities selected for the assessment amounted to EUR 1,525 million, of which EUR 885 million (57% of the total effects) represented the value of destroyed physical assets, and EUR 640 million (43% of the total) refer to losses in production. When considering all the 38 affected municipalities, the total value of disaster effects rose to EUR 1.7 billion (or over 4% of GDP).

- The hardest hit sectors were energy and agriculture (32% of the total), followed by housing, transport and trade, each accounting for around 15%.

- Flood protection infrastructure suffered as well, leading to increased concerns over power and food shortages and leaving the country even more exposed to subsequent flooding.

- Approximately 51,800 people temporarily lost their job due to the interruption of productive activities and household incomes declined proportionally.
**WB DRM Wide Support**

- Establishment of a National Disaster Risk Management Program (NDRMP) to coordinate efforts to boost resilience throughout the country.
- The initial $300 million (recently revised to $245 million) Emergency Recovery Loan from WB to support the recovery efforts after floods in 2014 in the energy, agriculture and flood protection sectors.
- The first ($70 million) Disaster Risk Management Development Policy Loan from WB in the region to take advantage of the Catastrophe Deferred Drawdown Option (Cat-DDO).
- EU and WB support of EUR6.15 million, creation of high resolution Digital Terrain Models using advanced LiDAR survey technology to better assess future flood risks.
- SDC and WB support of $1.6 million for institutional strengthening, open data initiatives and end-to-end early warning system development. BEWARE

- Shifting focus over time from flood prevention and recovery to multi-hazard risk management at both the local and national levels.
- Expanding DRM approaches to selected sectors such as transport and urban planning for improved resilience.
- Strengthening financial protection mechanisms to protect against fiscal shocks of natural hazards. (CAT DDO)
- Mitigating the impact of climate change and making the economy more disaster resilient.
- Managing and implementing the National DRM Program.
- Supporting regional initiatives on risk assessment, resilient planning, preparedness and response.
Transport context

• Connectivity is a critical driver of competitiveness, and the quality of infrastructure networks is an important factor for Serbia to shift the economy towards export-orientation.

• World Bank ongoing investment lending projects, Corridor X Highway Project, Road Rehabilitation and Safety Project, and P4R are complementing the government’s efforts to improve the quality of road infrastructure.

• In 2016, the World Bank supported the preparation of a Joint Action Plan that was endorsed by the 6 Governments of the Western Balkans at the Western Balkan Paris summit in July. This action plan included amongst other the development of Network Resilience plans and the Identification of interventions for climate mitigation and increased network efficiency, and preparation of draft plans for their implementation. – regional project and SEETO
The World Bank Transport team is supporting the GoS to mainstream climate resilience in the road sector through:

a) Ongoing and planned investment projects \(\Rightarrow\) interventions and policy support

b) Pilot-testing of the Handbook/Toolkit for Geohazard Risk Management in Transport Sector (Geohazard Handbook) \(\Rightarrow\) provide diagnostics of the current state of affairs and identification of major improvements needed; and

c) Mainstreaming climate resilience in road transport management in Serbia with support of the Global Facility for Disaster Reduction and Recovery Trust Fund Facility (GFDRR) \(\Rightarrow\) methodology for vulnerability assessment, RAMS, GIS...
Main initial findings (Geohazard Handbook testing)

The preliminary analysis from the Handbook testing suggests that there is no established methodology for systematic management of the network vulnerability. In particular:

• Climate resilience is considered only on an ad-hoc basis and is usually driven by the expert knowledge of few employees from PERS.

• There is no clear regulation governing how the investments in potentially critical locations should be planned or financed; in addition usage of available resources is inefficient.

• Serious lack of equipment (inclinometers, piezometers, etc.) has been reported and observed in the most severe existing landslide locations.

• Design legislation and guidelines for geohazards in the road network have been defined as sufficient and recently strengthened to comply with the European standards, however insufficient funding limits considerably its application and results in insufficient instrumentation and geotechnical designs.

• Cooperation between central and local relevant government agencies is insufficient. The authority dealing with emergency situations (SES) and PERS should work more closely, interact and share data, utilizing available Early Warning Systems and jointly respond in a timely and combined manner in emergency situations.

• There is lack of historical and observational data to monitor the climate change sensitivity/vulnerability of different sectors and ecosystems on the basis of unified and recognized system of indicators; in addition, spatial data are insufficient and/or publicly unavailable. Traffic and statistical data are available.

• Data on landslides are partially recorded in the relational database, but there is no established road vulnerability map in GIS environment.

• There is lack of unified and publicly available methodologies for elaboration of climate change related assessments;

• Insufficiency of regional coordination mechanisms. The high exposure and vulnerability and a up to now a reactive approach to disasters, as well as environment degradation factors urge a need to further work on mainstreaming climate resilience of the road transport network and improvement of disaster risk management and emergency response in Serbia.
Mainstreaming climate resilience in the road transport management in Serbia (GFDRR grant, 200K)

Objectives:

- support the government in establishing a foundation for mainstreaming climate resilience considerations in the road transport sector management in Serbia by developing an effective methodology for assessing vulnerability of the road transport network to the climate related risks,
- improving capacities of key stakeholders in road network climate resilience planning, and
- setting the path for development of structured and systematic response plans.

- Test the proposed methodology/guidelines and road asset management on Pilot region around Valjevo (200 km) with the use of GIS
- Framework and all outputs are expected to be applicable to the entire country and to any road class
- IMC Worldwide and Faculty of Geology and Mining, University of Belgrade
### Specific tasks

<table>
<thead>
<tr>
<th>Task 1: Methodology for Climate Change and Natural Hazard Road Network Vulnerability Assessment (and beyond)</th>
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<tbody>
<tr>
<td>• Vulnerability assessment <strong>methodology</strong></td>
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<tr>
<td>• <strong>Framework</strong> for prioritization of interventions based on vulnerability and criticality criteria</td>
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<tr>
<td>• <strong>Guidelines</strong> for climate change and natural hazard road network vulnerability assessment</td>
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<tr>
<th>Task 2: Recommendations for Inclusion of Climate Resilience in the Road Asset Management and Corresponding Action Plan</th>
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<td>• Develop recommendations for actions across the full scope of road asset management and action plan.</td>
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<tr>
<td>• Monitoring and observation * Financing</td>
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<tr>
<td>• Investment Decision Making Framework * Institutional and legal reforms</td>
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<td>• Asset Life Cycle Strategy Adjustments</td>
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<tr>
<th>Task 3: Pilot Testing of the Proposed Approach for the Valjevo Region and Development of corresponding GIS Maps</th>
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<tbody>
<tr>
<td>• Vulnerability assessment and asset plans pilot testing with corresponding GIS maps</td>
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<tr>
<th>Task 4: Development of a ToR for Network Vulnerability Analysis and Emergency Response Plans for the Main Trade Routes</th>
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<tr>
<td>• Policy frameworks, disaster response mechanisms</td>
</tr>
<tr>
<td>• Protocols for traffic queuing and coordination, evacuation routes, etc and Disaster communication protocols and equipment</td>
</tr>
<tr>
<td>• Procurement, Financial planning and protection</td>
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<tr>
<td>• Establishing sectoral disaster assessment teams and provision of risk understanding, awareness, and technical training</td>
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<th>Task 5: Dissemination and Knowledge Sharing Workshops</th>
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• Identify existing and likely future key hazard types and risk levels (e.g. riverine floods, erosion, high temperatures, landslides, etc.)

• Assess demographic and socioeconomic data and identify areas with high densities of population, especially the poor or other vulnerable people;

• Identify the location of (a) critical services and (b) major economic activities, existing and planned. Assess economic potential of high risk areas

• Identity priority geographical areas and road links that are vulnerable to existing and future climate driven risks.
Translate methodology for easy to use guidelines, applicable and understandable to central and local authorities

- What parts of the road network cross areas with high climate related hazard(s) and what is the risk level
- What kind of socio-economic impacts could be generated in the case of hazard events on particular road(s)
- How to prioritise critical road interventions for investment (both in the current climate conditions / related hazards and for future climate change projections); and
- How to develop estimated budgets prioritising mitigating and resilience measures with respect to climate and natural hazard events

Guidelines for climate change and natural hazard road network vulnerability assessment

**Task 1:** Identify relative exposure of different areas of the country to natural hazards (for baseline & future year scenarios)

**Task 2:** Identify those roads that pass through those areas of particularly high levels of exposure to natural hazards

**Task 3:** Determine socio-economic importance of these roads, to identify the most important/critical areas of the network

**Task 4:** Carry out engineering-based assessment of critical roads to estimate their vulnerability to natural hazards & their risks.

**Task 5:** Identify & cost site-specific engineering interventions necessary to improve the road assets’ resilience to natural hazards

**Task 6:** Assess costs of other non-site-specific interventions necessary to improve the road assets’ resilience to natural hazards

**Task 7:** Use multi-criteria methodology to prioritise the list of specific interventions

**Task 8:** Develop budgeted multi-annual plans & annual programmes of prioritised interventions.
1. Exposure of different areas to natural hazard
2. Identify roads passing to high exposure areas

Task 2: Identify those roads that pass through those areas of particularly high levels of exposure to natural hazards.

Input: Natural hazards exposure maps:
- Current year
- Medium term
- Long term

Output: List/map of roads & their level of exposure to natural hazards:
- Current year
- Medium term
- Long term

Figure 2: Flowchart for Task 2: identify those roads that pass through those areas of particularly high levels of exposure to natural hazards.
3. Socio economic importance of roads

<table>
<thead>
<tr>
<th>Task 3.1</th>
<th>Determine socio-economic importance of these roads, to identify the most important/critical areas of the network.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input:</td>
<td>Traffic-related (ADT)</td>
</tr>
<tr>
<td></td>
<td>Road distribution</td>
</tr>
<tr>
<td></td>
<td>Populations served On road</td>
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<tr>
<td></td>
<td>Industrial &amp; agro-cultural centers</td>
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<tr>
<td></td>
<td>Access to roads services (schools, hospitals, transport centers)</td>
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<td></td>
<td>Road transport policies</td>
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<tr>
<td></td>
<td>Other criteria</td>
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**Road transport policies:**

**Task 3.2:** Acquire necessary socio-economic data
- From existing sources
- From data collection

**Task 3.3:** Harmonize / standardize data for analysis

**Task 3.4:** Prioritize road links and their level of socio-economic importance

**Output from Task 2:**
- List of all roads and their level of exposure to natural hazards
  - Current year
  - Medium term
  - Long term

**Output from Task 3:**
- List of the most important road links that pass through areas with high level of exposure to natural hazards
  - For current year (2019)
  - For medium term (20 years to 2039)
  - For long term (50 years to 2099)

**Figure 3:** Flowchart for Task 3: Determine socio-economic importance of these roads, to identify the most important/critical areas of the network.
4. Engineer based assessment for vulnerability

Task 4: Carry out engineering based assessment of critical roads to estimate their vulnerability to natural hazards & their risks.

Input: Listings of the most important road links that pass through areas with high level of exposure to natural hazards.

For current year (2019):
- Assess and rank road sections vulnerability to each type of natural hazard (0-1).

For medium term (20 years to 2040):
- Assess and rank road sections vulnerability to each type of natural hazard (0-1).

For long term (50 years to 2070):
- Assess and rank road sections vulnerability to each type of natural hazard (0-1).

Table 4.3

<table>
<thead>
<tr>
<th>Exposure Level (0-1)</th>
<th>Natural Hazard</th>
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<tbody>
<tr>
<td>High</td>
<td></td>
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<tr>
<td>Medium</td>
<td></td>
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<tr>
<td>Low</td>
<td></td>
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Table 4.3

<table>
<thead>
<tr>
<th>Level of Vulnerability</th>
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<tbody>
<tr>
<td>Low</td>
</tr>
<tr>
<td>Medium</td>
</tr>
<tr>
<td>High</td>
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Table 4.3

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<thead>
<tr>
<th>Genetic (Design) Weaknesses</th>
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<tr>
<td>Genetic (Design) Weaknesses</td>
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</table>

Output: List (6 maps) of road assets with the highest risk from natural hazards.

Figure 8: Flowchart for Task 4: Carry out engineering based assessment of critical roads to estimate their vulnerability to natural hazards and their risks.
5&6. Identify & cost (site and non-site) specific interventions

**Task 5:** Identify & cost site-specific engineering interventions necessary to improve the road assets’ resilience to natural hazards.

- **Output from Task 4:**
  - Impact List/Site Map of road assets with the highest risk from natural hazards.

- **Task 5.1:** Select assets/sites & access for further investigation.

- **Task 5.2:** Assess asset of problems & remedial options to mitigate or restore risks from natural hazards.

- **Task 5.3:** Select preferred site-specific engineering interventions.

- **Task 5.4:** Quantify works required.

- **Task 5.5:** Apply unit costs & other engineering cost data to estimate costs for specific engineering interventions.

**Output:** List/Site Map of recommended engineering measures on specific road assets with their costs prioritised according to their risks from natural hazards.

**Task 6:** Assess costs of other non-site-specific interventions necessary to improve the road assets’ resilience to natural hazards.

- **Output from Task 4:**
  - List of generic (design) weaknesses contributing to higher risks from natural hazards.

- **Task 6.1:** Identify remedial measures to increase road assets’ resilience to natural hazards.

- **Task 6.2:** Estimate extent of remedial measures.

- **Task 6.3:** Estimate Unit Costs and Apply Other Cost Estimates.

- **Task 6.4:** Cost Estimates of Generic, Non-Site-Specific Interventions.

**Initial Output:** Overall list of extent of non-site specific.

**Task 6.5:** Cost Estimates of Generic, Non-Site-Specific Interventions.

**Output:** List of generic (design) weaknesses contributing to higher risks from natural hazards.

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**Figure 5:** Flowchart for Task 5: Identify and cost site-specific engineering interventions necessary to improve the road assets’ resilience to natural hazards.

**Figure 6:** Flowchart for Task 6: Assess costs of other non-site-specific interventions necessary to improve the road assets’ resilience to natural hazards.
7&8. Multi-criteria prioritization and investment plans

Task 7: Use multi-criteria methodology to prioritise the list of specific interventions.

- Task 7.1: Specify specific criteria for prioritisation.
- Task 7.2: Determine the importance of each criterion.
- Task 7.3: Assign multi-criteria prioritisation methodology to specific interventions.

Input: List (or map) of recommended engineering measures on specific road assets, with their costs prioritised according to their risk from natural hazards.

Output: List of prioritised interventions to increase the road assets' resilience to the effects from climate change.

Task 8: Develop budgeted multi-annual plans & annual programmes of prioritised interventions.

- Task 8.1: Identify different budget headings.
- Task 8.2: Assign each intervention to each budget heading.
- Task 8.3: Assign each intervention to relevant budget heading in order of their priority and funds are exhausted.
- Task 8.4: Repeat assignment of remaining interventions for each year until completed.

Output: Multi-year plan of prioritised climate mitigating interventions on road assets.

Output: First year annual programmes of prioritised climate mitigating interventions on road assets.

Figure 7: Flowchart for Task 7: Use multi-criteria methodology to prioritise the list of specific interventions

Figure 8: Flowchart for Task 8: Develop budgeted multi-annual plans and annual programmes of prioritised interventions.