Mapping of climate vulnerabilities on existing national road network in Poland

General Directorate for National Roads and Motorways (GDDKiA)
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Brussels, 6th of June 2019

JASPERS Networking Platform - Second workshop on Climate Change Adaptation in the Transport Sector
Adaptation to climate change for national roads in Poland

- GDDKiA

- The Project

- Stage I: Summary and main conclusions ≈ Previous workshop…

- Stage II: Summary results

- Stage III: initial workshops reflections…

- Suggestions
17 650 km of National Roads

1,627 km of motorways

1,809 km of expressways
Traffic intensity on national roads

<table>
<thead>
<tr>
<th>Road category</th>
<th>Length - 2010</th>
<th>AADT 2010</th>
<th>Length 2015</th>
<th>AADT 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorways</td>
<td>848</td>
<td>23285</td>
<td>1556</td>
<td>26509</td>
</tr>
<tr>
<td>Expressways</td>
<td>550</td>
<td>19567</td>
<td>1484</td>
<td>21232</td>
</tr>
<tr>
<td>Main trunk roads</td>
<td>11203</td>
<td>10434</td>
<td>10536</td>
<td>9995</td>
</tr>
<tr>
<td>Trunk roads</td>
<td>4646</td>
<td>4978</td>
<td>4446</td>
<td>5260</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>17247</strong></td>
<td><strong>9888</strong></td>
<td><strong>18022</strong></td>
<td><strong>11178</strong></td>
</tr>
</tbody>
</table>
The Project

Planned project steps

Stage 1: Analysis of survey results, data validation and road network vulnerability assessment including climate change projections

Stage 2: Assessment of costs and impacts of extreme weather events

Stage 3: Workshop of all related stakeholders to identify adaptation responses based on risks assessment

Stage 4: Build the “business-case” on national road network adaptation for decision-makers

Stage 5: Action Plan for the recommended adaptation measures

Sept 2017

Sept 2019
Stage I

Stage 1:
- **Analysis** of survey results, data **validation** and road network **vulnerability** assessment including **climate change projections**

Stage 2:
- Assessment of **costs and impacts** of extreme weather events

Stage 3:
- **Workshop** of all related stakeholders to identify adaptation responses based on **risks assessment**

Stage 4:
- Build the “**business-case**” on national road network adaptation for decision-makers

Stage 5:
- **Action Plan** for the recommended **adaptation measures**

Sept 2017

Sept 2019
Background and Stage I

Background

• Beyond the project level - Need to understand the overall network vulnerability to CC
  • In 2016 GDDKiA conducted a survey on weather-related affections of national road network:
    • Period covered January 2004- April 2016
    • Send to all 16 regional offices
    • Data provided:
      • 3,300 extreme weather events required actions of road service teams

• In 2017 Jaspers Advisory and GDDKiA established horizontal project: “Adaptation to CC for national roads in Poland”
Stage I: Survey results analysis

**Percentage distribution of weather causes of registered events**

<table>
<thead>
<tr>
<th>Event</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire</td>
<td>0.2%</td>
</tr>
<tr>
<td>Heat and high temperatures</td>
<td>2.4%</td>
</tr>
<tr>
<td>Frost and low temperatures</td>
<td>4.1%</td>
</tr>
<tr>
<td>Intensive rainfall</td>
<td>22.3%</td>
</tr>
<tr>
<td>Hail</td>
<td>0.5%</td>
</tr>
<tr>
<td>Intensive snowfall</td>
<td>15.5%</td>
</tr>
<tr>
<td>Ice accretion on road and road</td>
<td>2.7%</td>
</tr>
<tr>
<td>lightning discharge</td>
<td>3.0%</td>
</tr>
<tr>
<td>Reduced visibility (fog)</td>
<td>3.0%</td>
</tr>
<tr>
<td>Strong wind</td>
<td>32.6%</td>
</tr>
<tr>
<td>Flood</td>
<td>8.4%</td>
</tr>
<tr>
<td>Other</td>
<td>5.3%</td>
</tr>
</tbody>
</table>

**Annual average number of registered events per 100km of a given road class**

- **Motorways**: 0.83
- **Expressways**: 0.87
- **Main trunk roads**: 1.53

8
Stage I: Survey results analysis

Percentage distribution of the different Classes effects of registered weather events

<table>
<thead>
<tr>
<th>Class</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>19.7%</td>
</tr>
<tr>
<td>I</td>
<td>12.5%</td>
</tr>
<tr>
<td>II</td>
<td>23.9%</td>
</tr>
<tr>
<td>III</td>
<td>1.3%</td>
</tr>
<tr>
<td>I+II</td>
<td>35.2%</td>
</tr>
<tr>
<td>I+III</td>
<td>0.5%</td>
</tr>
<tr>
<td>II+III</td>
<td>1.5%</td>
</tr>
<tr>
<td>I+II+III</td>
<td>5.3%</td>
</tr>
</tbody>
</table>

Time of occurrence of registered weather events

<table>
<thead>
<tr>
<th>Month</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>17.9%</td>
</tr>
<tr>
<td>II</td>
<td>6.4%</td>
</tr>
<tr>
<td>III</td>
<td>4.5%</td>
</tr>
<tr>
<td>IV</td>
<td>2.8%</td>
</tr>
<tr>
<td>V</td>
<td>11.9%</td>
</tr>
<tr>
<td>VI</td>
<td>10.7%</td>
</tr>
<tr>
<td>VII</td>
<td>15.7%</td>
</tr>
<tr>
<td>VIII</td>
<td>7.3%</td>
</tr>
<tr>
<td>IX</td>
<td>3.4%</td>
</tr>
<tr>
<td>X</td>
<td>4.7%</td>
</tr>
<tr>
<td>XI</td>
<td>4.2%</td>
</tr>
<tr>
<td>XII</td>
<td>10.8%</td>
</tr>
</tbody>
</table>
Initial conclusions summary

- Identified main climate hazards affecting national road network (intense rainfall, intense snowfall and strong winds – over 70% of all registered events). - Confirming initial KLIMADA assumptions. (Other hazards with longer-term effects e.g. heatwaves could not be captured by present study)
- Higher number of events occurred on national roads other than motorways and expressways (build based on higher design standards and operated under higher maintenance standards, other national roads often presenting poorer condition status).
- Most of events occurred in May-July and December-January.
- Data enabled GIS environment representation as key for further vulnerability analysis.
- About 10% of all recorded events resulted in complete blocking of the road (i.e. high impact on users and economy). Most commonly caused by heavy rain, heavy snow and flooding.
- A solid prelude to further work under the Jaspers supported project “Adaptation to climate change for the national roads in Poland”.
- A basis to state that adequate and well-planned adaptation measures can translate into direct benefits for GDDKiA, road users and the economy.
Stage I: Climate change forecasts

- **Observed trends:**
  - Systematic temperature (T) increase since late nineteenth century (in particular since 1989).
  - Precipitation (P) changed but no unidirectional tendencies and high geographical variability.
  - Frequency increase of severe weather events.
- Few studies devoted to climate change forecasts in Poland.
- Lack of a platform with easy access to climate change scenarios and climate data: 
  KLIMADA 2.0 project by IOŚ-PIB on-going
- **Climate forecasts:**
  - increase in annual average T (in particular, in winter) with increase of Ndays with Tmax>25°C and decrease of Ndays with Tmin<0°C;
  - changes in P, differing forecasts, generally increase (winter P would increase while summer would decrease), increase in Pmax24h and increase of Ndays with P>10 mm/day and P>20 mm/day;
  - decrease in Ndays with snow cover and reduction in maximum snow cover;
  - increased frequency and intensity of wind.
Stage I: Climate change forecasts

Trends and forecasts: some graphs....

Difference in number of days with Tmax>25°C between 1971-2000 and 2041-2070. Source: KLIMADA.

Trends of number of days with precipitation ≥50 mm. Source: KLIMADA.

Incidents (yearly number) of whirlwinds in Poland. Source: IMGW.

Difference in days with P>10 mm/day (left) and P>20 mm/day (right) between 1971-2000 and 2041-2070. Source: KLIMADA.
Stage I: Climate change forecasts

Forecasts...

Difference in number of days with P>20mm horizon 2050. Source: IOS.

Difference in total annual precipitation, horizon 2050. Source: IOS.

- Data obtained from IOS (National Environmental Institute) while platform not available.
- Not all planned indices for the project available though

Input for Stage III...

Average number of heatwave days, 2021-2030. Source: IOS.
Stage I: Vulnerability assessment

Current vulnerability: initial conclusions

**Vulnerability**

\[ \text{Vulnerability} = \text{Sensitivity} \times \text{Exposure} \]

- **Sensitivity** = Identifying the relevant climate hazards: interventions of road maintenance service teams, infrastructure damage and/or traffic disruptions
- **Exposure** = Considering location: number of registered events and climate data and projections considerations

Number of registered events and impact levels caused by all weather hazards.

All weather registered events sensitivity levels.
Stage I: Vulnerability assessment

Current Vulnerability Assessment: initial results – three main hazards
Stage II

Stage 1: • **Analysis** of survey results, data **validation** and road network **vulnerability** assessment including **climate change projections**

Stage 2: • Assessment of **costs and impacts** of extreme weather events

Stage 3: • **Workshop** of all related stakeholders to identify adaptation responses based on **risks assessment**

Stage 4: • Build the **“business-case”** on national road network adaptation for decision-makers

Stage 5: • **Action Plan** for the recommended **adaptation measures**

Sept 2017

Sept 2019
Stage II: Costs and impacts assessment

Overview of impacts

- **Infrastructure assets**
  - Others
  - Fires
  - Heat and high temp
  - Low temperatures
  - Heavy rain
  - Hail
  - Heavy snow
  - Ice on the road
  - Lighting
  - Limited visibility
  - Wind
  - Flooding

- **Infrastructure operations**
- **User operations**

**Damage cases by extreme and affected party**

Stage II: Costs and impacts assessment

Impacts on road infrastructure

**Average cost per type of damage (PLN)**

<table>
<thead>
<tr>
<th>Types of road infrastructure elements</th>
<th>Number of actions</th>
<th>% of all actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slopes damages and landslides</td>
<td>30</td>
<td>35.3%</td>
</tr>
<tr>
<td>Drainage system damages</td>
<td>7</td>
<td>8.2%</td>
</tr>
<tr>
<td>Pavement and road surface damages</td>
<td>9</td>
<td>10.6%</td>
</tr>
<tr>
<td>Bridges and structures damages</td>
<td>5</td>
<td>5.9%</td>
</tr>
<tr>
<td>Other damages</td>
<td>9</td>
<td>10.6%</td>
</tr>
<tr>
<td>Drainage &amp; Pavements</td>
<td>2</td>
<td>2.4%</td>
</tr>
<tr>
<td>Slopes/landslides &amp; Drainage</td>
<td>7</td>
<td>8.2%</td>
</tr>
<tr>
<td>Maintenance cleaning &amp; Other damages</td>
<td>7</td>
<td>8.2%</td>
</tr>
</tbody>
</table>

Based on a sample of 88 events from registers from Katowice, Krakow, Opole, Rzeszow, Warsaw and Wroclaw GDDKiA branch offices. (*) 3 records needed to be excluded from average to avoid distortion.

General average cost of an event with registered damages (based on the sample):

92,000 PLN (*)
(approx. 20,500 EUR)

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Average cost per type of damage (PLN)

- Slopes damages and landslides: 44,342 PLN
- Drainage system damages: 4,810 PLN
- Pavement and road surface damages: 36,312 PLN
- Bridges and structures damages: 113,300 PLN
- Other damages: 25,660 PLN
- Maintenance cleaning: 3,570 PLN
Stage II: Costs and impacts assessment

The case of 2010 flooding

<table>
<thead>
<tr>
<th>Damage type</th>
<th>Number of actions</th>
<th>% of all actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slopes damages and landslides</td>
<td>11</td>
<td>5.1%</td>
</tr>
<tr>
<td>Drainage system damages</td>
<td>7</td>
<td>3.2%</td>
</tr>
<tr>
<td>Pavement and road surface damages</td>
<td>17</td>
<td>7.9%</td>
</tr>
<tr>
<td>Bridges and structures damages</td>
<td>31</td>
<td>14.4%</td>
</tr>
<tr>
<td>Slopes/landslides &amp; Drainage &amp; Pavements</td>
<td>9</td>
<td>4.2%</td>
</tr>
<tr>
<td>Drainage &amp; Pavements</td>
<td>67</td>
<td>31.0%</td>
</tr>
<tr>
<td>Slopes/landslides &amp; Drainage</td>
<td>12</td>
<td>5.6%</td>
</tr>
<tr>
<td>Slopes/landslides &amp; Pavements</td>
<td>5</td>
<td>2.3%</td>
</tr>
</tbody>
</table>
Stage II: Other impacts

Impacts on road operations: the winter maintenance

- 66% of all registered events incurred traffic disruptions and only 8.7% caused traffic blocking

<table>
<thead>
<tr>
<th>Weather Factor</th>
<th>Traffic flow disturbance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up to 1 h</td>
<td>1-12 h</td>
</tr>
<tr>
<td>Strong Wind</td>
<td>18.8%</td>
<td>39.6%</td>
</tr>
<tr>
<td>Heavy Snow</td>
<td>1.5%</td>
<td>43.9%</td>
</tr>
<tr>
<td>Heavy Rain</td>
<td>5.1%</td>
<td>17.1%</td>
</tr>
</tbody>
</table>

- Statistics: number of accidents is higher under most favourable weather conditions
Stage III

Stage 1: Analysis of survey results, data validation and road network vulnerability assessment including climate change projections

Stage 2: Assessment of costs and impacts of extreme weather events

Stage 3: Workshop of all related stakeholders to identify adaptation responses based on risks assessment

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Stage 5: Action Plan for the recommended adaptation measures
Stage III: Workshops

Katowice GDDKiA Branch – 15/11/18

Gdansk GDDKiA Branch – 05/03/19

Wroclaw GDDKiA Branch – 11/04/19
Stage III: Workshops

List oddziaływań na drogi krajowe

Oddziaływania związane z wydłużonym/intensywnymi opadami deszczu:
- uszkodzenia dróg (naświerzch, el. ziemięnych i in. towarzyszącej) oraz systemów;
- zwiększony odpływ z przylegających terenów powodujący powódzie;
- powodzi;
- zwiększone nieistotność nachylen i osuwiska;
- zwiększone podmokanie dróg, mostów i fundamentów obiektów;
- pogarszanie się stabilności podłogi z powodu podwyższoną wilgotności;
- redukcja ograniczanie;
- Częstszaa utrata przyczepności nawierzchni (sliktosć) - zaburzenia płynności ruchu.

Oddziaływania związane z opadami śniegu:
- zwiększone/zmniejszone zapotrzebowanie na ośnieżanie i utrzymanie zimowe;
- zwiększone ilość topniejącego śniegu prowadzące do powodzi;
- zwiększone ilość zaburzeń płynności ruchu.

Oddziaływania związane z wiatrem i burzami:
- różne zagrożenia: polamane drzewa, zniesienie infrastruktury, latające przedmioty;
- uszkodzenia znaków drogowych, ekranów akustycznych itd.;
- ograniczenia ruchu w odległym terenie (np. wysokie pojazdy itd.)
- zwiększona liczba dachów znajdujących się wiatrem i burzami;
- zaburzenia płynności ruchu.

**Table:**

<table>
<thead>
<tr>
<th>Oddział</th>
<th>Klasa drogi (A, S, DK)</th>
<th>nr drogi (gminy)</th>
<th>nr gminy</th>
<th>Hazard</th>
<th>Assessment of future impacts</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katowice</td>
<td>DK 24023972</td>
<td>Kozy</td>
<td>Heavy rain</td>
<td>4</td>
<td>Road under bad condition and presenting several incidents related to heavy precipitation</td>
<td></td>
</tr>
</tbody>
</table>
Stage III: Workshops

Brainstorm on climate vulnerabilities, issues and potential adaptation responses

- Legislation not precise for Road management and Nature conservation to share responsibilities
- Different administrations responsible for adjacent land to road network with different maintenance levels
  “A1 motorway accused to cause flooding to adjacent land”
- Current procurement practice (contract award on lowest-price) leading to low-quality designs and low-cost effectiveness solutions….
- …..

- Review legislation
- Joint action of different managers/ operators/ administration levels
- Review embankment designs materials
- Need of specific funding: not only under routine maintenance
- ….
Stage III: Workshops

Brainstorm on climate vulnerabilities, issues and potential adaptation responses

- Strong winds is causing particularly problems to old trees and on noise screen on animal passes
- Problems of flooding adjacent lands
- Lack of sufficient coordination of different administrative levels in case of events
- ...

- Regular control of old trees and on new planting considerations on the trees species and time of the year
- Increase of drainage pipes system could increase capacity as well as facilitate maintenance and cleaning to be done
- Considerations on design and adequate maintenance levels of drainage systems
- ...
Another main project pillar

- **Analysis** of survey results, data **validation** and road network **vulnerability** assessment including **climate change projections**
- **Assessment of costs and impacts** of extreme weather events
- **Workshop** of all related stakeholders to identify adaptation responses based on **risks assessment**
- Build the “**business-case**” on national road network adaptation for decision-makers
- **Action Plan** for the recommended **adaptation measures**

-----Raising awareness -----Knowledge Sharing-----International cooperation-----
Suggestions
Thank you!

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glutczyk@gddkia.gov.pl
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:

jaspersnetwork@eib.org

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JASPERS Website: jaspers.eib.org