Workshop on project preparation process with reference to EU and WBIF requirements

Climate Change Vulnerability and Risk Assessment

Assen Antov, JASPERS
12 October 2022, Belgrade
# Climate Change Vulnerability and Risk Assessment

<table>
<thead>
<tr>
<th>Purpose</th>
<th>To identify the risks for the project from climate change and formulate measures for avoiding or mitigating the negative impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditions</td>
<td>There needs to be clarity on the main parameters of the project</td>
</tr>
<tr>
<td>Results</td>
<td>Action plan for avoiding or mitigating the negative impacts of climate change</td>
</tr>
<tr>
<td>Timing</td>
<td>Preparation as part of the Feasibility Study; implementation of the action plan during project’s lifecycle</td>
</tr>
</tbody>
</table>
**Legal framework**

- **Invest EU Regulation** – Article 8(5) stipulates that financing and investment operations shall be *screened* to determine whether they have an environmental, *climate* or social impact.

- **CEF Regulation** – Article 14(2) requires that ‘the assessment of proposals against the award criteria shall take into account, where relevant, the resilience to the adverse impacts of climate change through a *climate vulnerability and risk assessment* including the relevant adaptation measures’.

- **Common Provisions Regulation** – Article 73(2) (j) stipulates that the managing authority in selecting operations shall ensure the *climate proofing* of investments in infrastructure with an expected lifespan of at least five years.
Methodology

• Recommendations for methodology included in EC’s “Climate Change and Major Projects” (2016)

• The methodology is reproduced in EC’s “Technical Guidance on the Climate Proofing of Infrastructure Investment Projects in the period 2021-2027” (2021)
Definitions and concepts (1)

- **Climate change adaptation** – the process of improving the resilience of infrastructure to climate change

- **Climate change mitigation** – human intervention aimed at limiting the emissions of greenhouse gases or improving their absorption rates

- **Climate proofing** – includes *both* climate change mitigation and adaptation; one of the three pillars of *sustainability proofing*, i.e.: climate, environmental and social proofing
Definitions and concepts (2)

• **Extreme weather-related events** – the main subject of analysis within the framework of climate change vulnerability and risk assessments (examples to follow)

• Extreme weather-related events result in **negative impacts** on the components of infrastructure (i.e. of the assets), as well as on the users (i.e. on the services)

• Extreme weather-related events are directly linked to the changes of one or more **climate variables / indices**

  (e.g. maximum volume of precipitation for 1 – 5 days during the year, number of days with snow cover, number of days with precipitation above a certain threshold, number of dry days, number of days with precipitation, average daily / monthly / annual temperature, minimum / maximum temperature, etc.)
• **Vulnerability assessment** – combines *qualitative* measures of the sensitivity of the project to extreme weather-related events and its exposure to the events with the purpose to *identify the most important vulnerabilities*:

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

• **Sensitivity** – a measure of the strength of the negative impacts from the occurrence of an extreme weather-related event. It is determined *independent* of project’s location

• **Exposure** – a combined measure of the *strength and frequency* of occurrence of an extreme weather-related event, considering project’s location
Risk analysis – combines (usually) *qualitative* measures of the impact and probability of occurrence of extreme weather-related events, in order to identify the most important risks for the project:

\[
\text{Risk level} = \text{Impact level} \times \text{Likelihood level}
\]

Impact – a measure of the strength of the negative impact of the occurrence of a risk (i.e. extreme weather-related event)

Likelihood – a measure of the probability of occurrence of a risk (i.e. extreme weather-related event)
Terrain instability (as a result of intense rainfall)
Examples

Flood
Examples

Damaged road construction (as a result of intense rainfall)
Examples

Damaged road construction (as a result of high river levels)
Examples

Damaged pavement (as a result of freezing-thawing cycles)
Examples

Low visibility (because of fog)
Examples

Destroyed bridge (as a result of foundation scour)
Examples

Damages to property from hail
Examples

Collision of multiple vehicles (as a result of low visibility, because of snow)
1.1 How was CC considered in the project preparation process (i.e. as a factor in the option analysis or with an ex-post assessment)?

- It is highly recommended that the CC VRA is integral part of project preparation (i.e. *ex-ante* analysis)
- It is also acceptable to take CC into account at later stages (i.e. with *ex-post* analysis)
1.2 What extreme weather-related events are considered?

- A summary of the extreme weather-related events being analysed

1.3 Is the list of events exhaustive and detailed enough?

- The list needs to cover a sufficiently big set of potential vulnerabilities
- It is critical to specify the link:
  \[ \text{cause} \Rightarrow \text{event} \Rightarrow \text{negative effects} \]
- Also critical to explicitly link the extreme event and climate variables
1.4 Are the potential negative effects on the project identified for each event?

- The negative effects from the extreme weather-related events must be identified in detail.
- The effects on *assets and services* must be separately evaluated.
- The assessment must consider the expected *lifetime* of the infrastructure components.
- It is possible to consider the effects on separate infrastructure components – e.g. pavement, drainage, structures, accessories, etc.
The definition is **too general** – extremely high temperatures have completely different impacts on the infrastructure than extremely low temperatures.
Examples

Definitions of extreme events

Example 2:
• Extremely high temperatures
• Extremely low temperatures

The more specific definition allows the events to be connected to:
• specific causes through meteorological variables (e.g. minimum / maximum temperature for the year, number of days with temperature lower / higher than a threshold, number of hot / cold days, etc.); and
• specific negative effects (e.g. higher / lower bitumen plasticity, hence emergence of rutting / cracks; pavement aging; bridge dilation issues; etc.)
Examples

Definitions of extreme events

Example 3:
• Extreme precipitation

Too general definition – rain, snow and hail have different negative effects on the assets and services.
**Examples**

Definitions of extreme events

Example 4:
- Extreme rainfall
- Extreme snowfall
- Hail

😊

The more specific definition allow the events to be connected to:
- specific *causes* through meteorological variables (maximum rainfall for 1 or 5 days; number of wet days; maximum / average snow cover; number of days with snowfall; number of days with hail; etc.); and
- specific *negative effects* (e.g. reduced visibility; reduced traction; damages to embankments / cuts; increased costs for cleaning of snow; interruptions of operation …)
Example 5:
• Extreme snowfall

### Causes (defined by observable meteorological indices):
• maximum snowfall for 1 or 5 days
• maximum and average height of the snow cover
• number of days with snowfall
• number of days with snow cover

### Negative effects (expressed by the direction of change in economic costs):
• ↓ visibility ⇒ ↑ risk of accidents ⇒ ↑ economic costs
• ↓ traction ⇒ ↑ risk of accidents ⇒ ↑ economic costs
• intensive snowmelt ⇒ excess capacity of drainage systems ⇒ damage to embankments/cuts (⇒ damage to the road structure) ⇒ ↑ repair costs
• ↑ costs for pavement treatment and snow removal
• ↑ emergency response costs
• disrupted operation ⇒ ↑ economic costs
2.1 Is the sensitivity of both assets and services separately considered?

2.2 With regard to sensitivity of assets, is the *lifetime* of the asset noted and taken into account?

2.3 Is sensitivity also considered from the point of view of interdependencies?

• The sensitivity of the *assets, services and the links* between the systems must be evaluated as a minimum
• Even better is to evaluate the sensitivity of the *infrastructure components* and different *aspects of the services*
• The *lifetime* of the assets should me considered in the evaluation
2.4 Are sensitivity levels defined?

- Usually 3 levels are defined – low, medium and high
- At this stage, it is not strictly necessary to search for quantitative (objective) measure of the levels

2.5 Is sensitivity determined independent of project’s location (that is, independent of its exposure)?

- The sensitivity considers the strength of the negative effects in case of occurrence of an extreme weather-related event
To evaluate sensitivity, four categories (themes) are used. The highest occurred level is awarded, which leads to a too conservative analysis. Unclear what the sensitivity levels mean. (Also, too general definitions of the events.)
2.6 Are the sources of current and future climate data used listed?

2.7 What is the level of aggregation of the data used in the analysis (EU-level, national, regional) and is it adequate?

- The sources of data and climate forecasts must be listed
- The data and forecasts must be sufficiently detailed and to consider the local specifics
- For evaluation of past climate trends, local data must be used
- For evaluation of future trends, it is acceptable to use forecasts and models at macro level (e.g. EU)
2.8 Does exposure adequately take into account the location of the project?

- … i.e. the expected strength and frequency of the extreme weather-related event at the specific location
- *The exposure is likely to be different for different parts of the project!*

2.9 Are present and future exposure determined separately?

- Future exposure must also be evaluated.

2.10 Are exposure levels clearly defined?

- Usually three exposure levels are used
Examples

Exposure analysis

It is unclear what the exposure levels mean. Considering the higher of the two levels (for present and future exposure) makes the analysis too conservative.
Levels of exposure to floods:

- **Low** – unthreatened territory or with flood recurrence interval of more than 100 years
- **Average** – territory with flood recurrence interval between 20 and 100 years
- **High** – territory with flood recurrence interval lower than 20 years

The definition of exposure levels allows unambiguous interpretation and link with quantitative indicators.
2.11 Is the sensitivity vs. exposure matrix unambiguously defined?

- The matrix must reflect the sensitivity and exposure levels and show the resulting vulnerability levels

2.12 Is the ranking of vulnerabilities in accordance with the levels proposed by EC’s “Climate Change and Major Projects”?

- Usually three levels are used
The meaning of the different vulnerability levels must be defined. The analysis is too conservative – using this methodology projects get classified with medium to high vulnerability to almost all extreme weather-related events.
Using GIS the future vulnerability is determined for discrete spatial units.
2.13 Common sense check – are there any vulnerabilities that seem under- or overrated?

• An attempt to eliminate *serious errors* and omissions

2.14 Is there a conclusion whether the project is considered vulnerable or not?

2.15 If the project is not considered vulnerable, is this conclusion justified by the vulnerability analysis?

• Using the methodology from “Climate Change and Major Projects”, in reality there is no chance the project is considered non-vulnerable…
3.1 Are the most important vulnerabilities carried to the risk assessment (i.e. the ones with high and medium level)?

- Often consultants continue evaluating *all* vulnerabilities…
3.2 Does the probability scale follow the recommendations of EC’s “Climate Change and Major Projects”?

- (Not mandatory)
- The levels must be compatible with the qualitative risk analysis of the project
3.3 How are likelihoods determined and is the method reasonable?

- It is important to determine likelihood levels based on actual statistical data
- “Expert opinion” is not the recommended approach

3.4 Common sense check – are there any likelihoods that seem under- or overrated (both in absolute terms and relative to each other)?

- An attempt to identify and address serious errors and omissions
Examples

Data for the frequencies of extreme events

Number of extreme weather-related events on railway infrastructure (2012 – 2017)

Source: National strategy and action plan for climate change adaptation (Bulgaria, 2018)
3.5 Does the severity of impact scale follow the recommendations of EC’s “Climate Change and Major Projects”?

- (Not mandatory)
- There are five levels – insignificant, minor, moderate, major, catastrophic
- The levels must be compatible with the qualitative risk analysis of the project
3.6 Are adequate criteria ("risk areas") taken into account when assessing the severity of impacts?

- The impact level of a risk depends on the values and objectives of the evaluators, i.e. it is subject to *multi-criteria analysis* (or even cost-benefit analysis)
- Risks must be *mutually independent*
- The analysis must distinguish between *risks* and their *effects*
- It is highly recommended that the different impact evaluation criteria ("risk areas") are *quantitatively determined*
- The impact evaluation criteria must also be *mutually independent*
- It is extremely important to define the *strength of occurrence* of each risk, because the impact depends directly on it
Too general and ambiguous criteria – what is “Engineering”, and how is it supposed to be evaluated? What exact effects does “Social” represent? Why someone’s reputation is considered of equal importance with the health and safety of the public? What does “Environment” evaluate (the analysis must be focused on how CC affects the project)?
Examples

Criteria for evaluation of the impacts of risks

• Costs for the operators of infrastructure assets (e.g. repairs, emergency response, loss of income, etc.)
• Health and safety (of the users and the personnel of the operators)
• Costs to users because of interrupted services (e.g. increased traveltime, increased operational costs)
• Social impacts (e.g. reduced access to social services, to agricultural land, isolation of communities, etc.)

😊
The negative effects are specific and can be quantified. If they are further decomposed to sub-criteria, it will be possible to quantify most of them in terms of economic costs.
### Data, supporting the evaluation of impacts

#### Damages to railway infrastructure from catastrophic events (2012 – 2017)

<table>
<thead>
<tr>
<th>Event</th>
<th>Events (number)</th>
<th>Events with damages (number)</th>
<th>Damages (BGN)</th>
<th>Damage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floods</td>
<td>84</td>
<td>14</td>
<td>7,007,558</td>
<td>37.8</td>
</tr>
<tr>
<td>Landslides</td>
<td>69</td>
<td>6</td>
<td>10,724,672</td>
<td>57.9</td>
</tr>
<tr>
<td>Rockfalls</td>
<td>139</td>
<td>14</td>
<td>723,709</td>
<td>3.9</td>
</tr>
<tr>
<td>Snow</td>
<td>34</td>
<td>8</td>
<td>78,494</td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>326</td>
<td>42</td>
<td>18,534,433</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: National strategy and action plan for climate change adaptation (Bulgaria, 2018)
3.7 Are the risk areas focused on risks in the project context and are they sufficiently detailed?

- The criteria must evaluate the impacts on the project

3.8 When determining the severity of impacts, are existing adaptation measures external to the project taken into effect?

- If there are such measures, they need to be taken into account
3.9 Does the analysis consider any planned adaptation measures?

- The analysis must not take into account adaptation measures, planned or implemented in the project context.

3.10 Common sense check – are there any impacts that seem under- or overrated (both in absolute terms and relative to each other)?

- An attempt to identify serious errors and omissions
- Pairwise comparisons of impact levels
3.11 Does the probability vs. severity scale appear unbiased (e.g. not too optimistic?)

- It is recommended to work with 3 risk levels
- The risk matrix must be unambiguously defined
- The scale must ensure *weak consistency* between the risk levels and the quantitative interpretation

3.12 Are risk levels determined correctly in accordance with the risk matrix?

- I.e. if the calculations are correct…
3.13 Common sense check – are there any risks that seem under- or overrated (both in absolute terms and relative to each other)?

- An attempt to identify serious errors and omissions
- *Pairwise comparisons of risk levels!*
3.14 Are prevention and mitigation measures identified for each risk?

3.15 Are the measures reasonable and realistic?

3.16 How are any adaptation options compared?

- Adaptation options – possible measures for risk prevention and/or mitigation of impacts

- In the CC VRA context, usually it is not necessary to formulate and compare adaptation options, and an action plan can be directly defined
3.17 Is there a detailed and realistic action plan?

3.18 Are the entities responsible for enacting the adaptation options properly identified?

• Perhaps the most important part of the analysis is the identification of measures to avoid risks and/or mitigate their impacts.

• The measures must be detailed and specific in terms of scope, responsible entities, time and budget.

• The responsible entities must have the duty to implement the measures.

• Following up of the implementation of the plan must be ensured.
3.19 Is there an interpretation of the risk matrix included and does it properly address the levels of residual risk?

3.20 Do residual risks appear correctly determined?

3.21 Are there any significant residual risks to be left after implementing the adaptation actions?

- There needs to be an explanation how the adaptation measures influence the risks – i.e. the probability of their occurrence and/or their impact
- Verification whether the residual risk levels actually reflect the consequences of the mitigation measures
- Verification whether there are significant residual risks – there must be none
Wider issues

• A good place to start with increasing the adaptation capacity is the development of **national climate change adaptation strategies and action plans**

• Identifying vulnerabilities at project level is problematic. It is much better to develop **country-wide vulnerability assessments**

• For transport networks, it may be feasible to develop **country-wide criticality assessments**

• In order to be able to improve adaptation capacity, it is critical to review and improve **the data collection and management systems**
Coffee break