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PRE-SCANNING CLIMATE CHANGE IMPACTS ON TRANSPORT CORRIDORS – THE CASE OF SERBIAN WATERWAYS

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Abstract

South Eastern Europe (SEE) will experience more extreme weather conditions over the next ten years with stronger influence on transport infrastructure. Within ClimaCor project (2016) a methodology for identifying climate change threats, evaluating their impact on transport corridors and defining adaptation measures is developed. ClimaCor II (a part of ClimaCor initiative) is about applying this pre-scanning methodology on two SEE Transport Corridors. This paper presents main findings of ClimaCor II concerned with those segments of the TEN-T Rhine-Danube International Waterway that passes through Serbia. The methodology is based on experts' opinions on current and future risks. The most influential threats are mapped along the waterway corridor and adaptation measures are recommended.

Key words: *climate change, transport infrastructure, pre-scan methodology*.

1 INTRODUCTION

The expression “climate change” is used to indicate alterations in the Earth’s “pattern of weather, meaning the averages, the extremes, the timing, the spatial distribution not only of hot and cold, but of cloudy and clear, humid and dry, drizzles and downpours, snowfall, snowpack, snowmelt, blizzards, tornados, and typhoons” [1]. Although the contribution of transport to climate change is more in focus now days [2] there is a strong need to address the opposite impact - how changed climate and weather conditions affect the current and future availability and safety of transport corridors.

The principal aim is to include climate change adaptation in transport policy and planning. There are many definitions of climate change adaptation [see 3, 4, 5], but in essence they all refer to the ability to moderate or avoid harm as a result of climate change impact.

For this purpose several evaluation schemes in the field of transport have been developed. One of them is devised within the project ROADAPT (ROADs for Today, ADAPTed for Tomorrow) in 2012 [6].

On the basis of ROADAPT - ‘Quick Scan on climate change risks for road’ [7], during 2015 and 2016 a new methodology was developed and labelled ClimaCor - Climate Impacts along Transport Corridors. The aim was to offer rapid assessment methodology easily applied in short time and based on experts' opinions. After initial application (Spain, Ukraine and Portugal) ClimaCor methodology (labelled as ClimaCor II) was further used to assess climate change impacts on transport corridors (rail, road and waterways) in SEE.

According to the latest reports on climate change in Europe [8, 9] it is expected for weather conditions in SEE to be characterized by higher temperatures, reduced rainfall, droughts, flash floods, low level water, etc. Along there are some inconclusive findings regarding wind, ice and fog. Sources on foreseen climate changes conditions do not directly foresee periods of extreme wind (mostly because they count on averaged seasonal values) and also frequently have great uncertainties, but circuitously it can be projected for extreme winds to appear (as a consequence of extreme weather events like convective storms) [9]. Moreover, the largest temperature increases during the 21st century are expected over southern Europe in summer with extremes projected to become more frequent and last longer [10].

In respect to the above outlined climate change characteristics in SEE, and the fact that transport sector is particularly vulnerable to these conditions (see [11] for comprehensive discussion) it is of importance that targeted investments in innovative solutions that take into account the climate change threats [9]. It is also of importance to do this in collaboration between the neighbouring countries so to successfully capitalize on opportunity to support the implementation of the “South East Europe 2020 Strategy” [12] (and EU acquis).

This paper is about applying ClimaCor II methodology to assess climate threats on in SEE with focus on waterways (particularly the Sava and the Danube River in Serbia). The paper is organized as follows. Next section is about ClimaCor II methodology. Section three contains main results concerned with SEE waterway corridors in Serbia followed by discussion on adaptation measures. The paper ends with concluding remarks.

2 CLIMACOR II PRE-SCAN METHODOLOGY

ClimaCor methodology was developed from December, 2015-September, 2016 under a forerunner project financed by the Netherlands Ministry of Infrastructure and Environment as a contribution to the UNECE's Group of Experts on Climate Change Impacts and adaptation for Transport Networks and Nodes. In the first phase the methodology was applied to two transport corridors: Kyiv (Ukraine) - Chisinau (Moldavia) and Lisbon (Portugal) - Madrid (Spain).

From July to December, 2016 a joint initiative of Regional Environment Center (RCC), Regional Cooperation Council (RCC) and South East Europe

Transport Observatory (SEETO) was launched on order to refine and simplify the ClimaCor methodology and apply it on two west Balkan corridors (waterway, road/rail).

The ClimaCor II methodology is structured around three phases of activities: surveying, a validation workshop, and corridor reporting inclusive of recommendations for adaptation measures. It can be lined with the framework of the TRB Committee on Climate Change and U.S. Transportation [13]. Also, the ClimaCor II is built around two lines of enquiry (horizontal/vertical): transport assets, filtered by their importance and by vulnerability to climate change; and climate change threats.

2.1. First phase - Surveying

The initial step is preparing the inventory of transport assets and preliminary list of relevant climate threats. Accordingly a survey questionnaire is prepared. Some important issues on conducting the survey were discussed during the special regional preparation meeting (in a form of a webinar). Five country experts managed the survey: from Bosnia and Herzegovina, Former Yugoslav Republic of Macedonia, Kosovo[1] and Serbia (two experts) The survey entailed online questionnaire and an interview with six groups of experts:

1. Transport infrastructure practitioners;
2. Transport demand management experts;
3. Climate change specialists;
4. Transport decision makers;
5. Environment decision makers and
6. Actively concerned climate/transport CSOs (civil society representatives)

The questionnaire contained the list of 42 threats [9] regarding transport infrastructure vulnerability associated with current and future risks imposed by climate change. During the survey preparation meeting the offered list of threats was discussed. Although each threat contained the indication of type of corridor (in the brackets) that is in line (road, rail, and/or waterways), during the webinar it was argued that this is questionable. For example threat number eight (T8) – '*Failure of flood defence systems of rivers and lakes due to long periods of rain in catchment area'* although indicated as important for rails and roads was also apprised with severe impact waterways. There were two solutions: to define a new list of threats especially designed for waterways, or to go with the full ClimaCor list. In order to retain comparability of ClimaCor I and ClimaCor II results and in the same time to test the applicability of ClimaCor II methodology for waterways it was decided to go with full initial list.

The questionnaire has several parts. First the respondents (experts) were asked to choose top ten climate change threats associated with the corridor under study. In the second step for each selected threat, the respondents' were asked about their views on the severity of its consequences to route availability/usability and human/route safety using predefined five-step scale (Table 1 and 2).

[1] This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.

Also, for each selected threat experts' expressed their views on its likelihood under: current meteorological conditions and ii) those foreseen (to 2050) due to climate change (using scale in Table 3).

Table 1 Levels of threat severity (impact on) route availability/usability

Score	Severity
1	Negligible impact on the availability (up to a few hours)
2	A minimal negative impact on the availability (up to a day)
3	A serious impact on the availability (several days, up to a month)
4	A catastrophic impact on the availability (more than a month of unavailable transport to significant number of people)

Table 2 Levels of threat severity (impact on) human&route safety hazard.

Score	Severity
1	A negligible impact on user safety (light material damage), injures that will not result on hospital visit
2	An influence that reaches the boundaries of acceptable user safety, with as a consequence a number of extra accidents with temporary loss of health or injures without absence (material damage, slight injures)
3	An influence to such extent that the boundaries of user safety are exceeded, with as a consequence a serious increase of the number of accidents with permanent loss of health (serious material damage, heavy injures)
4	A catastrophic influence on user safety, with as a consequence extra deadly danger during normal use (serious material damage, have injures, causalities)

Table 3 Levels of likelihood

Score	Likelihood
4	Often (more than once every 3 years)
3	Sometimes (once every 3 to 10 years)
2	Seldom (once every 10 to 50 years)
1	Very seldom (once every 50 years)

At the end the respondents' were asked to weight importance of route availability vs. safety (ratio). This was also questioned in the survey design. Namely some of the country' experts argued that this question is meaningless taking the argument that unsafe route is unavailable route. However there were some opposite opinions.

After collecting the answers from all engaged experts the results were compiled and contained the following:

- ranking of top threats according to 'popularity' - percentage of respondents who prioritized them;

- route availability and route safety based on the average scores that experts associated with each threat;
- weighting results – availability vs. safety ratio;
- the likelihood of each selected threat under two scenarios (current and foreseen climate conditions) based on averaged experts' scores;
- the degree of risk (a factor of consequence and likelihood) posed by each threat under each scenario;
- risk factor under current conditions and under foreseen climate change conditions

The future risk was estimated as a combination of previous results (last two bullets) to prevent overlooking threats with low likelihood and high consequences or vice versa. This can occur if the analysis is only based on the risk factor, which is the result on multiplying likelihood and consequences.
The results were visualized using predefined graphs.

2.2. Second phase - Validation

The results gathered through survey were validated during a workshop. Two working groups with minimum six members (consisting of experts from above mentioned categories) were asked to discuss the survey results and to validate them.
After reaching an agreement on the 'top threats', the experts mapped these threats (defined hotspots along the corridor). In the final stage of the validation workshop, for each of these threats experts suggested adaptation measures.

2.3. Third phase - Reporting

Based on the survey and validation workshop results country' experts compiled reports containing the inventory of transport assets and results of ClimaCor II methodology applied to the corridor under study. The draft report was sent to the engaged experts for review and/or confirmation. Based on the gathered comments the final country reports are prepared by country experts. Finally, the country reports were combined to obtain corridor assessment reports.

3 CLIMACOR II RESULTS FOR SERBIAN WATERWAYS

This section contains the ClimaCor II results for sections of the Sava River and the Danube River in Serbia (Sub-corridor TEN-T Rhine-Danube International Waterway, Figure 1).

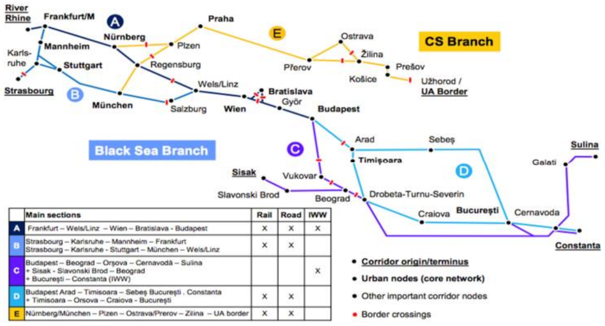

Fig. 1 *Alignment of the Rhine-Danube Corridor [9]*

More detailed discussion of the results can be found in [9].
Prior to the presentation of the results some key characteristics, of the Sub-corridor TEN-T Rhine-Danube International Waterway in Serbia are outlined.

3.1 Brief description of the corridor under study

The stretch of the Danube River through Serbia, from Bezdan in the North to Prahovo in the East, is 588 km long, which presents 20,6% of the total river length [14]. The Danube River is navigable throughout its course. The most important ports in Serbia for the transport of goods are in Belgrade, Novi Sad, Pančevo, Smederevo and Prahovo. The total volume of goods transported on the Danube River in Serbia reaches 6 million tonnes. Sector Futog is the most critical sector for navigation on the Danube River in Republic of Serbia. Characteristics of this sector are frequent changes in riverbed morphology and the available dimensions of the fairway (depth and width), causing frequent adjustment of position of the fairway [15].
The SEETO priority project for Serbian segment of the Danube River is related to river training and dredging works on critical sectors on the Serbia- Croatia joint stretch (129 km) and between Bačka Palanka and Belgrade (92 km) with around 220 million euros investment [16].
The Sava River is centrally located in the SEE core transportation network and navigation is possible in the upstream direction on total length of 594 km while Serbia has a sole responsibility for 178 rkm [17, 18]. The cargo handled in the Serbian ports on the Sava River in recent years was down to less than 25 thousand tons. The annual traffic volumes have dropped from over 5 million tons prior to political changes to less than 400.000 tons on the entire waterway [18, 19].
The navigation conditions of the Sava River are hampered by both natural conditions and lack of maintenance and investments. The main problems arise from: shallow depth of the navigation channel which limits draft over long period of time; sharp curves due to meanders limiting the length and width of vessels and convoys; strong fluctuation discharge resulting in strong variation in water levels and depths during the year; heavy sedimentation and a reduction in the width and depth of the fairway in certain areas; limited height under bridges at high water [19]. Critical sectors for navigation on the Sava River in the Republic of Serbia are Kamičak, Šabac, Klenak, Sremska Mitrovica and firth of the Drina River. In terms of available depth and width of fairway, firth of the Drina River is the most critical one [18, 19].
The SEETO priority project for Serbian segment of the Sava River is related to river training and dredging works on critical sectors (9 million Euros estimated costs for 211 km long stretch) [16].

3.2. Climate change impacts based on ClimaCor II results

Droughts over the last decade, coupled with low river maintenance, lack of dredging and riverbed surveying, have resulted in an increase of critical shallow waters on certain sections of the Danube and Sava Rivers, impeding their safe navigability [9]. Harsh weather conditions due to river surface icing or thick fog have also disrupted navigation.

Changes in water levels i.e. river flows are far the most influential on the navigation [20, 21]. Figure 2 illustrates some of major climate threats in Europe [8] where red means that (i) flood magnitude changes with more than 5 %, (ii) drought intensity changes with more than 5 %; and (iii) drought duration changes with more than 5%. It can be noted that SEE is in the 'red zone' meaning that more extreme weather conditions in terms of draughts and floods are expected.

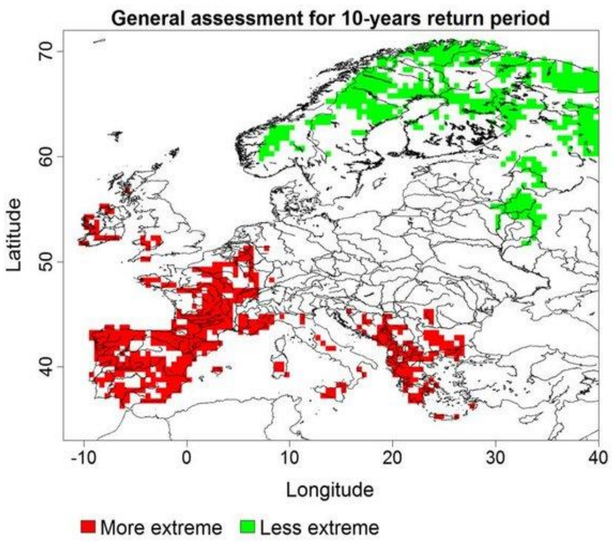

Fig. 2 *Summary of the changes in extreme river discharges over a 10 year period under a +2°C global warming scenario [8]*

Eighteen experts from different categories participated in Climacor II survey regarding Serbian waterways. Based on their opinions following results were obtained.

3.2.1. Severity, Importance, Likelihood

In Figure 3 'top 10' corridor threats are ranked based on popularity (survey group responses average). Threats T.5 and T.8 are sharing 10th place since they gained the same percentage of respondents who prioritized them.

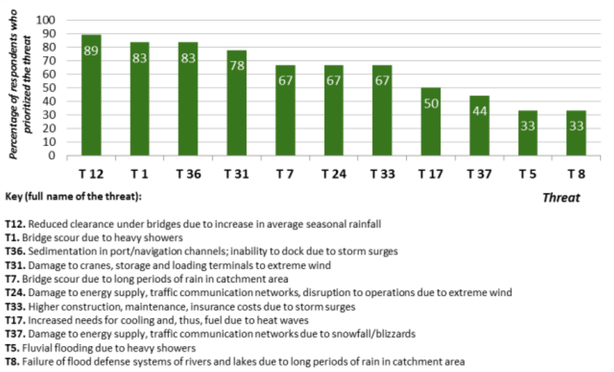

Fig. 3 *Ranking of Top Threats [9]*

According to experts' the importance of route availability vs. route safety, the results imply that the importance is nearly equal (4.7 for availability and 5.3 for safety). It is important to note that there was no consensus between experts. Their answers were very different and this equalization of importance is a consequence of averaging. Expected severity of each threat on route availability (usability) and human/route safety is given in Figure 4.

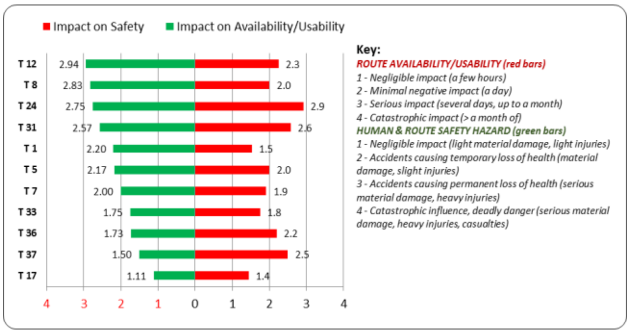

Fig. 4 *Level of impact severity for 11 "Top" threats[9]*

Several conclusions can be derived.

There is no threat with severity near the level 4 (catastrophic impact/ influence on availability and safety).

The route safety is found to be most vulnerable to *'Damage to energy supply, traffic communication networks, and disruption to operations due to extreme wind*' (T24) and *'Damage to cranes, storage and loading terminals due to extreme wind'* (T31). The level of impact severity was around three implying an influence that is to such extent that boundaries of user safety are exceeded, with consequence of serious increase of the number of accidents with permanent loss of health (serious material damage, heavy injuries).

'Reduced clearance under bridges due to increase in average seasonal rainfall' (T12) and '*Failure of flood defence systems of rivers and lakes due to long periods of rain in catchment area'* (T8) were judged as the ones with the most severe consequences on route availability /usability (around level 3 - serious impact on the availability with several days (up to a month) of unavailable transport).

Regarding the level of likelihood under climate change conditions, none of the threats is expected to appear more than once every three years (Figure 5).

'Sedimentation in port/navigation channels; inability to dock due to storm surges' (T36) and '*Damage to energy supply, traffic communication networks, disruption to operations due to extreme wind'* (T24) are expected to be most frequent, the consequences are probable to appear every 3 to 10 years.

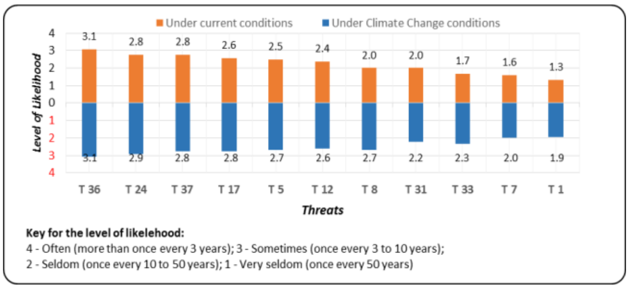

Fig. 5 *Level of threats' likelihood under current and foreseen climate conditions [9]*

'Bridge scour due to long periods of rain in catchment area' (T7) and *'Higher construction, maintenance, insurance costs due to storm surges'* (T33) will appear more often due to climate change conditions (from very seldom to seldom).

3.2.2. Risks

To highlight the degree of risk (a factor of consequence and likelihood) posed by each threat under each scenario, all 11 'top' threats are placed in the scatter plot where x-axis represents the severity of consequences while y-axis represents the level of likelihood (Figure 6 - left graph indicates current conditions and right is about climate change conditions).

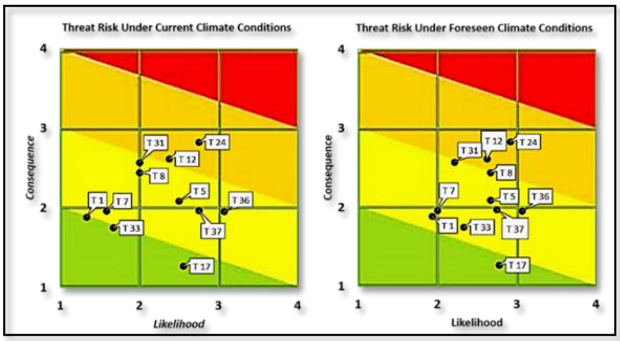

Fig. 6 *Relationship between likelihood and severity of the consequences for both scenarios [9]*

There are several conclusions coming from the scatter plot diagrams.
None of the 11 threats is located in the red part of the graph (Figure 6) which indicates the highest risk level.
'*Damage to energy supply, traffic communication networks due to snowfall/blizzards'* (T37) and '*Sedimentation in port/navigation channels; inability to dock due to storm surges'* (T36) have the same risk under both scenarios while all other threats show increased level of risk under climate change conditions in relation to the current conditions.
'*Damage to energy supply, traffic communication networks, disruption to operations due to extreme wind'* (T24) and '*Reduced clearance under bridges due to increase in average seasonal rainfall'* (T12) are two threats in the orange part of the graph related to current conditions (left graph in Figure 6).
Regarding foreseen climate change conditions (right graph in Figure 6), besides two above mentioned threats (T24 and T12) two more threats are positioned near the orange zone: '*Failure of flood defence systems of rivers and lakes due to long periods of rain in catchment area'* (T8) and '*Damage to cranes, storage and loading terminals to extreme wind'* (T31).
The risk factor for 11 most "top threats" is illustrated in Figure 7.

'Damage to energy supply, traffic communication networks, disruption to operations due to extreme wind' (T24) has the highest value of the risk factor, around eight (Figure 7). However this is also relatively low value knowing that the maximum value of the risk factor is 16.

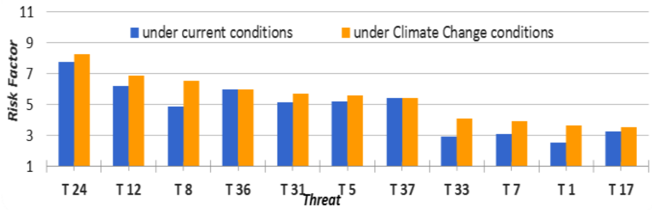

Fig. 7 *Risk under current conditions and under foreseen climate change conditions [9]*

'Higher construction, maintenance, insurance costs due to storm surges' (T33) although showing relatively low risk factor under both scenarios, has the highest increment in risk factor. Recalling the previous analysis on the likelihood, it can be conclude that this increment is the consequence of the higher likelihood/probability of T33.
As earlier explained in the methodology (section 2) results from scatter plots and results on risk factor are combined to prevent overlooking threats with low likelihood and high consequences or vice versa. Results from both graphs were considered under the foreseen climate change conditions i.e. future risks.
There are four threats with the relatively high risk factor (Figure 7), which also appeared in the orange zone in the likelihood/consequence two-dimensional plot (Figure 6, right graph). These four threats pinpoint to the most important future risks. They are: '*Damage to energy supply, traffic communication networks, disruption to operations due to extreme wind'* (T24); '*Reduced clearance under bridges due to increase in average seasonal rainfall'* (T12); '*Failure of flood defence systems of rivers and lakes due to long periods of rain in catchment area'* (T8) and '*Damage to cranes, storage and loading terminals to extreme wind'* (T31).
'Sedimentation in port/navigation channels; inability to dock due to storm surges' (T36); is also with high risk factor (even higher than T31). Although it is positioned in the yellow zone (Figure 6) it can be also seen as important future risk sign. It has the highest score on likelihood (among all 11 threats) and it was prioritized by over 80% of respondents (Figure 2).
'Fluvial flooding due to heavy showers' (T5) was also evaluated in terms of future risks due to relatively high risk factor (near T36) and the similar formulation as for T8.

3.2.3. Validation of results

The above mentioned six threats with highest future risks based in survey findings (T24, T12, T8, T31, T36 and T5) were validated during the workshop. Two working groups (diverse, one expert from each stakeholder group) discussed the findings/results previously presented, and determined whether they agree or not and to what extent they disagree with the priorities identified.
Both working groups agreed to move forward with mapping six above-mentioned threats (Table 4) with an important note that the most essential threat to the observed waterways was not covered by CLIMACOR II list. It can be generally formulated as <u>T* - Lower river flows due to climate change conditions (higher temperatures, droughts, floods and changes in</u>

precipitation intensity and distribution) and comes from the fact that for inland navigation on the Sava River and the Danube River, water level it is the hydrologic variable that is of utmost interest (see [21] for more thorough discussion). All experts emphasized that the results of the survey will be thoroughly different if the above mentioned threat was included in the list and consequentially the survey results would be more meaningful. The hotspots for this threat (labelled T*) are also mapped along the corridor. Threats T5 and T8 have the same locations, which confirms their similarity.

Table 4 Hotspots for the most severe threats [9]

Threat	Hotspot (rkm)
T24	The Danube River: Đerdap (I - 943 km, II-863km), Golubac (1036 km), Ram (1075 km), Veliko Gradište (1060 km), Pančevo bridge (1167 km)
T12	The Sava River: Old Rail Bridge (srb. Stari železnički most, 1.5 km)
T8	The Sava River: Šabac (101 km), Sremska Mitrovica (142 km), Sector Račanski (176-200 km) The Danube River: Staklar (1370 km) and Daljska (1359 km) in snow and ice conditions
T36	The Sava River: Sremska Mitrovica (142 km), Čukarica (3 km) The Danube River: Beočin (1267 km), Belgrade (1170 km), Pančevo (1253 km), Bačka Palanka (1296 km), Smederevo (1116 km), Prahovo (860 km)
T31	All ports with cranes: The Sava River: Šabac (101 km), Sremska Mitrovica (142 km) The Danube River: Apatin (1401, 5 km), Bogojevo (1366.5 km), Beočin (1269 km) Bačka Palanka (1295,5 km), Novi Sad (1252,6 km), Beograd (1167, 3 km), Pančevo (1154 and 1152,8km), Smederevo (1111 and 1116 km), Prahovo (862km)
T5	Same as T8.
T*	The Sava River: Firth of Drina, Sector Šabački (82-104 km), Sector Račanski (176-200); The Danube River: Apatin (1401 km), Futog (1262-1268)

Some additional remarks regarding sedimentation should be noted. Sedimentation can be an obstacle for navigation but its relation to the storm surges (T36) and seasonal rainfall (T12) should be thoroughly discussed. Namely this is not a direct impact, i.e. the erosion can appear as a consequence of storm surges and seasonal rainfall and consequently lead to sedimentation. Also, the experts suggested to address sedimentation in general not only in the port channels.

3.2.4. Adaptation measures

During the workshop the experts have recommended several adaptation measures for each mapped threat.

For damage to energy supply, traffic communication networks, disruption to operations due to extreme wind (T24) two adaptation measures are recommended. The first one is improvement of storm warning and prediction system. Namely, in order to forward forecasts in real time, storm surge warnings should include the prediction of maximum water levels, a general description of the expected wind and the moment of its expected maxima. The second recommended measure is consideration of climate change impact in the design of telecommunication systems. The most vulnerable part of these interacted systems to the wind is the overhead cabling infrastructure. In line, underground space should be maximized along with the provision of the backup connections.

To adapt to the reduced clearance under bridges due to increase in average seasonal rainfall (T12), experts recommended increasing the size of existing bridges and the design of new bridges in accordance with projections of future climate change. Raising the height of the existing bridges and new sizing requirements for the future bridge construction projects are welcomed engineering measures. They correspond to the return period, increase of the minimum freeboard, raise of span lengths. Also, relocation of bridge piers and foundations outside of main channels should be considered. Apropos construction materials, concrete components like piers could be reinforced with more steel to deal with the need for strength and rigidity.

Three measures are recommended to deal with the fluvial flooding due to heavy showers and/or long periods of rain. (Threats T8 and T5):

- Early warning system - based on integration of meteorological data into hydrological models, the automated data communication system for the entire river basin should be created. To be timely responsive, the system should be decentralized and should include the instructions to the public. Where short time reaction is required (urban areas) reliable warning levels have to be achieved based on real time measures of rain intensities. The under-or over prediction of the hazard caused by uncertainty of the parameter values in hydrological models, is the major risk in operating early warning systems.
- Strengthening and/or construction of hydro-technical structures for water protection and reinforcement of coastal embankments - the measures should improve the design of solid building structures like weirs, channels and dams to withstand mechanical or physical effects of flooding water; construction of longitudinal and transverse hydraulic structures which regulate the flow of water; placing rocks lope protection which consists of one or more layers of rock along the critical stretches of the river; addition of the crest wall to raise the height of the defence on flood bank; strengthening embankments with internal central core made from impermeable substance, etc.
- Construction and maintenance of water protection zones. Prevention from vegetation (forests and bushes) loss is important for the protection of drainage, and against shore cutting and sliding.

To address the Sedimentation in port/navigation channels; inability to dock due to storm surges (T36) experts recommend:

- Investment in maintenance of ports and navigation channels (deepening) to ensure access. Dredging activities to safeguard required depths are required to deal with the deposition of sediment, as a natural product of erosion that decreases the depths of navigation channels. Due to high maintenance costs, the rates and timing for sediment removal should be based on regular monitor of water levels. The removing is carried out in line with predefined recommendation (e.g. if the filling of the bottom of water bodies is higher than 20cm)
- Erosion remediation. Having that root system of the restored vegetation can significantly strength the bank, forestation of river banks is an effective method of erosion control.

Damage to cranes, storage and loading terminals due to extreme wind (Threat T31) should be addressed with:

- Consideration of extreme winds for operational assets location and port design. Using simulation based models in searching for optimal locations and port configuration and operation processes.
- Early warning system improvement and equipment adaptation to extreme winds. Ensure that terminals are subscribed to a contract weather service that provides specialized weather forecast for the operating area of the port. The equipment should be designed to provide an initial alert-cranes equipped with anemometers to indicate wind speed at the highest stationary point of the crane. The shutdown and other secure procedures should be provided for each port facility.

As emphasized earlier experts engaged in survey pointed to the 'missing' threat in ClimaCor II list. This is lower river flows due to climate change conditions (higher temperatures, droughts, floods and changes in precipitation intensity and distribution) labelled as T*. Regarding adaptation measures the experts recommended the transition in fleet design and operation. It includes solutions related to application of light-weight structures, changes in designs and constructions of ships or installation of propellers with a smaller diameters. It would enable ships to operate at lower draughts.

4 CONCLUSION

In this paper the main climate change threats to navigation on The Sava and the Danube River are discussed. The threats along with adaptation measures are identified based on the findings of ClimaCor II methodology for rapid assessment of climate change impacts on transport corridors. The advantage of this methodology is in its simplicity and acknowledging the experts' opinions.

Namely it is easy to understand, applicable in a short time and it offers a platform for discussion among stakeholders. The weak point is its generality – the aim to address rail, road and waterway corridors with the same list of climate change threats. In the case of waterways this led to neglecting one of the major threats related to water levels. Accordingly, future refinements of this kind of pre-scan methodology should be transport mode specific.

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