Distr.: General
26 October 2023

English only

Economic Commission for Europe

Inland Transport Committee

Working Party on Transport Trends and Economics

Group of Experts on Assessment of Climate Change Impacts and Adaptation for Inland Transport

Twenty fifth session
Geneva, 30 and 31 October 2023
Item 6 of the provisional agenda
Guidelines for integrating climate change considerations in planning and operational processes

Impacts of climate/weather related events on transport infrastructure

Note by the secretariat

I. Introduction

1. Surveys on impacts of climate/weather related events on road/rail transport assets have been developed and disseminated. These surveys, one for rail and other for road infrastructure and operations focus on collection of data on incidents at transport assets which result in traffic/operational disruption with or without infrastructure damage due to precipitation and heatwave events. The surveys also aim at collecting data on costs of interventions and operational losses incurred as relevant.

2. The surveys were circulated between October and December 2022 to focal points of the Working Parties on Road and Rail Transport and to Trans-European Motorway and Trans-European Railway projects as well as to the International Union of Railways (UIC). The deadline for reporting was set for 31 March 2023.

3. For rail assets, surveys have been returned form the following countries: Czech Republic, France, Poland, Serbia, Slovakia, Slovenia, Türkiye, and the United Kingdom of Northern Ireland and Great Britain.

4. For road assets, surveys have been returned from Czech Republic, Portugal, Slovakia and Türkiye.

5. This document has been prepared to present initial analysis for the following four data sets:

- Railway disruptions caused by precipitation.
- Railway disruptions caused by heatwaves.
- Road disruptions caused by precipitation.
- Road disruptions caused by heatwaves.

6. For this analysis, for each the data set, obtained data have been merged in order to study the general trends but also to anonymize the analysis.

7. For every data set, various charts have been prepared to illustrate the data analysis. At the same time, it is noted that data obtained are not complete: in same cases no or limited data on costs of incidents were provided; in other, type of disruption or its duration were not recorded. Therefore, in cases where reported incidents were missing data on the analysed parameters, these incidents were excluded from the analysis.

8. For data on costs/losses, they are expressed in Euro at current currency exchange where the different purchasing power of currencies has not been considered. Also cost values reported as 0 have not been considered due to the fact that it was unclear whether incidents have caused no cost, or they were unknown/unreported.

II. Initial analysis of railway disruption

A. Caused by precipitation

9. Altogether, there have been 3814 incidents reported on railway disruption caused by precipitation. Unfortunately, only for 68 of them data have been provided on precipitation intensity which led to disruption resulting in costs. Figure 1 shows the distribution of incidents per precipitation intensity.

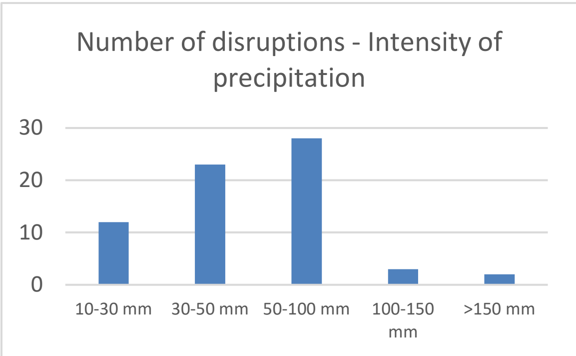

Figure 1: Incidents reported by given precipitation intensity

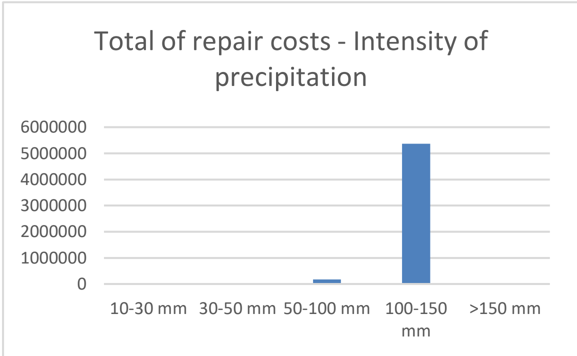

Figure 2: Total of repair costs per intensity of precipitation

10. The limited data show that majority of incidents have been caused by precipitation intensity between 50-100 mm followed by 30-50 mm per day. At the same time, these incidents did not cause much damage, as shown in Figure 2. It is the intensity of 100-150 mm per day that led to more significant cost of damage.

11. For type of damage per intensity of precipitation, these data have been provided for 97 incidents and are shown in Figure 3.

12. No clear correlation with the intensity of precipitation was found.

13. For type of disruption by intensity of precipitation, these data have been provided for 141 incidents and are illustrated in Figure 4.

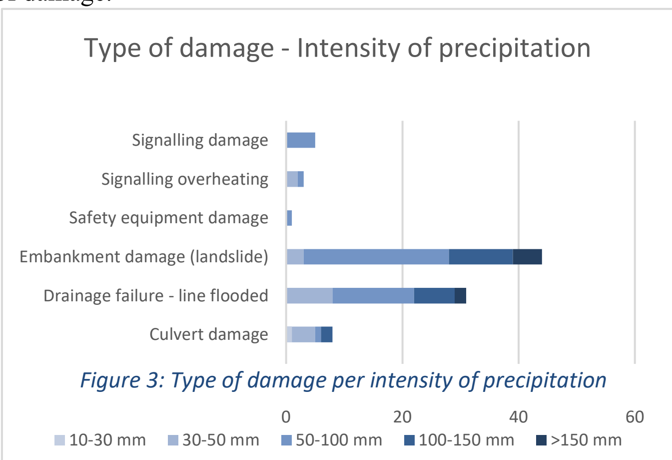

Figure 3: Type of damage per intensity of precipitation

Figure 3: Type of damage per intensity of precipitation

14. While most incidents led to speed reduction, which was caused already by relatively low precipitation intensity, long term line closure occurred almost entirely at intensity levels over 50 mm per day.

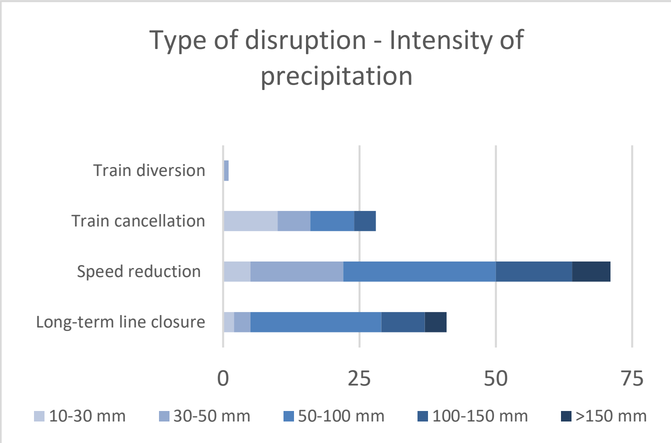

Figure 4: Type of disruption - intensity of precipitation

15. Heavy precipitation caused not just more costly but also longer disruption. As shown in Figure 5, and based on data for 176 incidents, the precipitation with an intensity higher than 100 mm per day caused in more than 60% of the cases a disruption longer than 3 hours. At the same time, the precipitation under 100 mm per day caused in almost 70% of cases a disruption shorter than 3 hours.

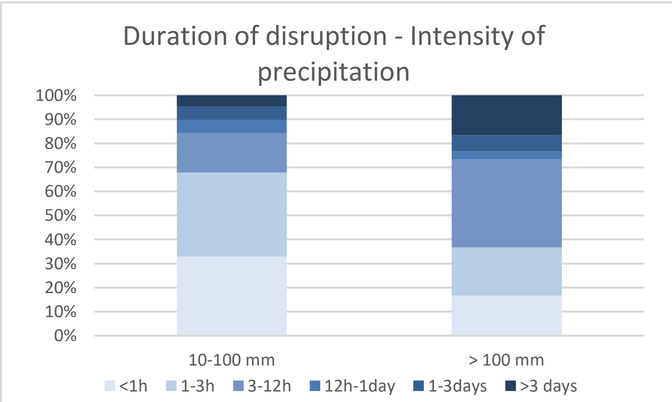

Figure 5: Duration of disruption - intensity of precipitation

16. The duration of disruption caused by precipitation events has been reported for 3310 incidents. Most of the disruption, as shown in Figure 6 lasted up to 1h. It is however the long-lasting disruptions that were responsible for high average repair costs, as shown in figure 7 or high total repair costs, shown in figure 8.

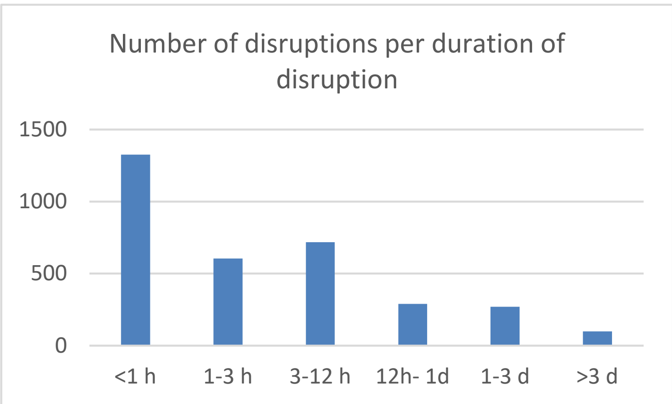

Figure 6: Number of disruptions - duration of disruption

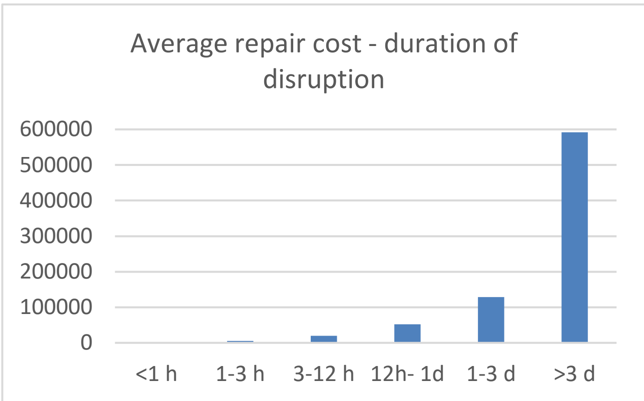

Figure 7: Average repair cost - duration of disruption

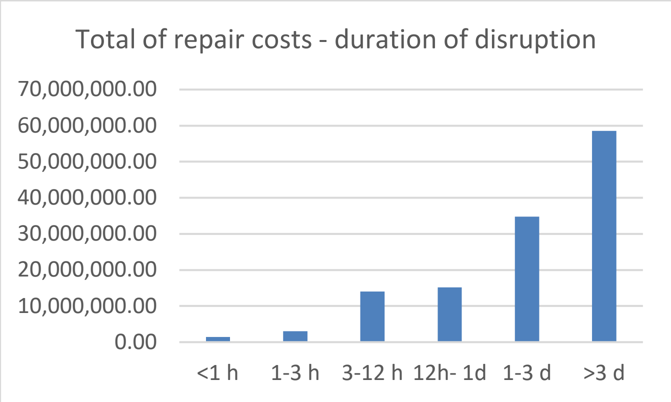

Figure 8: Total repair costs - duration of disruption

B. Caused by heatwaves

16. Altogether, there have been 2580 incidents reported on railway disruption caused by heatwaves. However, only for 15 incidents data have been provided on both temperature ranges and costs. These limited data show no correlation between higher temperature ranges and higher costs, as illustrated in figure 9, based on average costs of incidents reported.

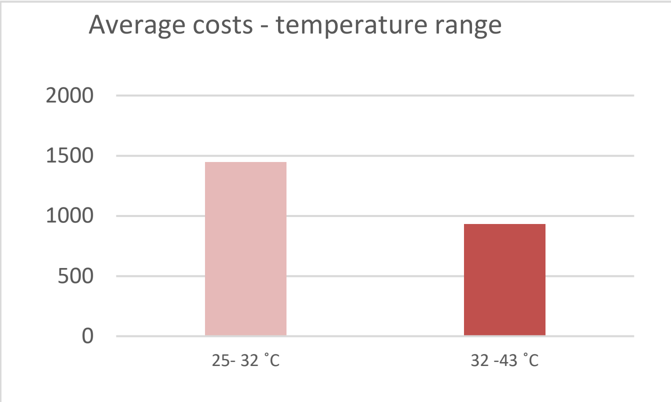

Figure 9: Average costs - range of temperature

17. For type of damage per temperature ranges, these data have been reported for 136 incidents and are shown in figure 10. Rail buckling and safety equipment damage were the most frequent type of damage reported, and they occurred mostly at the temperature between 32 and 43 degrees Celsius and above.

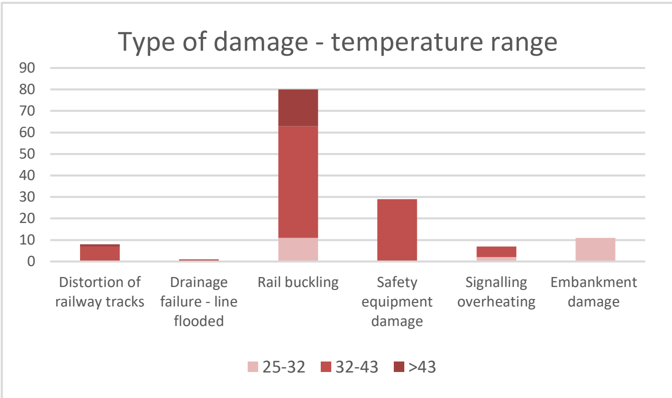

Figure 10: Type of damage - range of temperature

18. For type of disruption caused by heatwaves, these data have been reported for 184 incidents. The most frequent type of disruption was reduction in speed, as illustrated in figure 11a. Other types of reported disruptions are illustrated in figure 11b. As visible on both figures, most of the incidents were caused by temperature in the range between 32 and 43 °C. However, most of the reported train cancellations occurred on days with lower temperature. Temperature over 43 degrees Celsius led mainly to speed reduction in 18 cases and for one incident to long-term line closure.

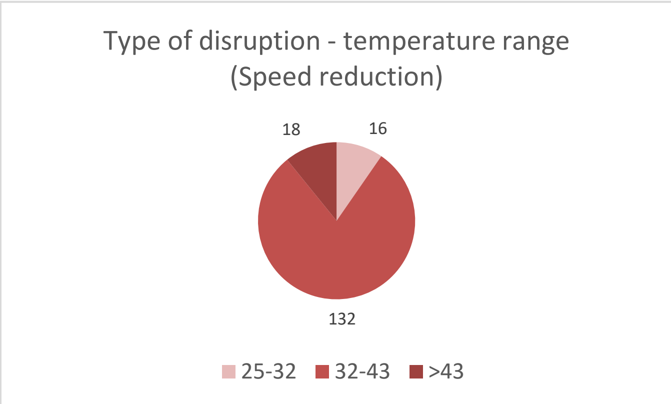

Figure 11(a): Type of disruption - temperature range

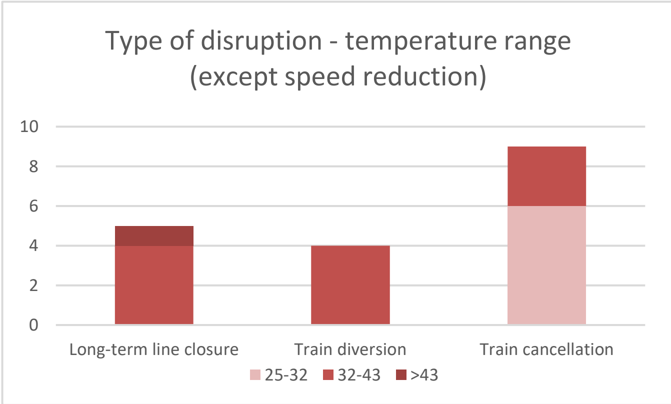

Figure 11(b): Type of disruption - temperature range

19. Regarding the duration of disruption depending on temperature, based on data for 194 incidents, as shown in figure 12, temperature above 32 degrees Celsius caused disruption which lasted less than 1h to more than 3 days.

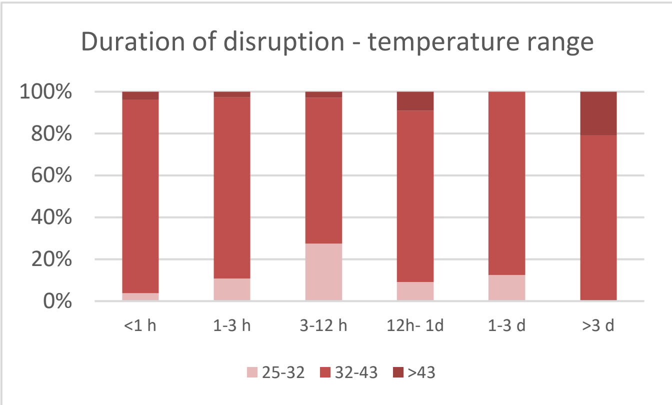

Figure 12: Duration of disruption - temperature range

20. The duration of disruption caused by heatwave events has been reported for 2172 incidents. Most of the disruption, as shown in Figure 13 lasted up to 1h. Like for precipitation events, the long-lasting disruption events were responsible for high average repair costs, as shown in figure 14. The total costs range highest for disruption duration of 1-3 days followed by 3-12h, as shown in figure 15.

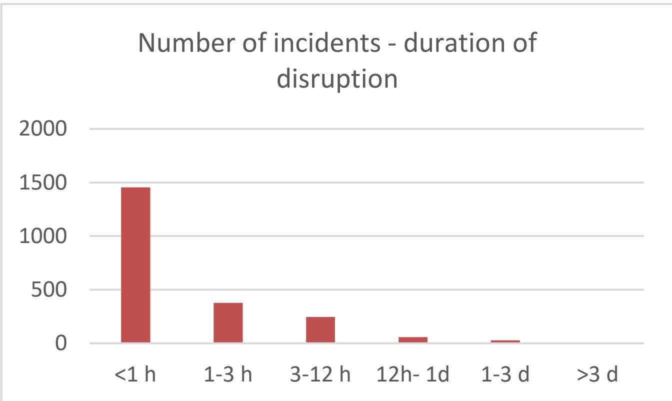

Figure 13: Number of incidents - duration of disruption

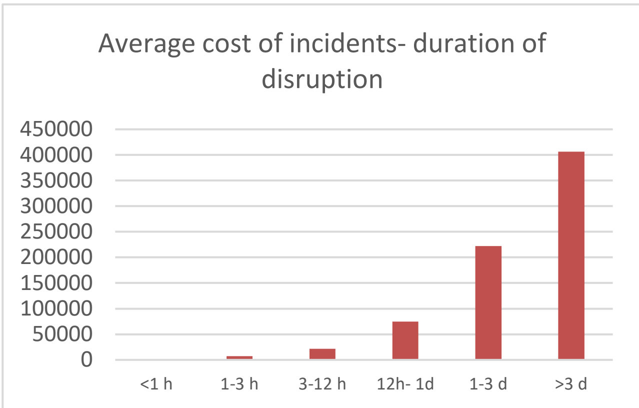

Figure 14: Average cost of incidents-duration of disruption

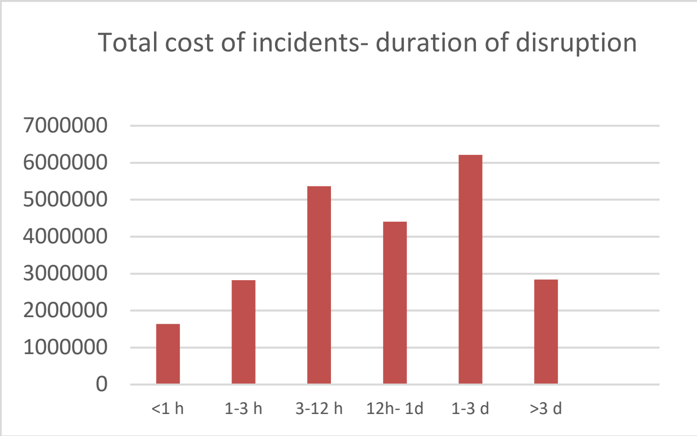

Figure 15: Total cost of incidents- duration of disruption

III. Initial analysis of road disruption

A. Caused by precipitation

21. Altogether, there have been 230 incidents reported on road disruption caused by precipitation. However, only for 37 of them data have been provided on precipitation intensity which led to disruption resulting in costs. Figure 16 shows the distribution of incidents per precipitation intensity.

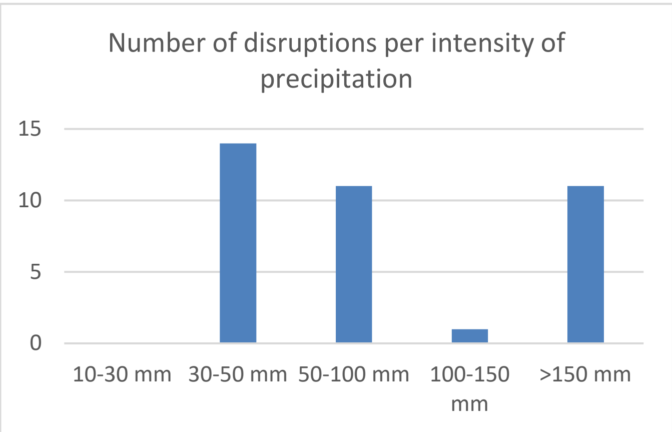

Figure 16: Number of disruptions - intensity of precipitation

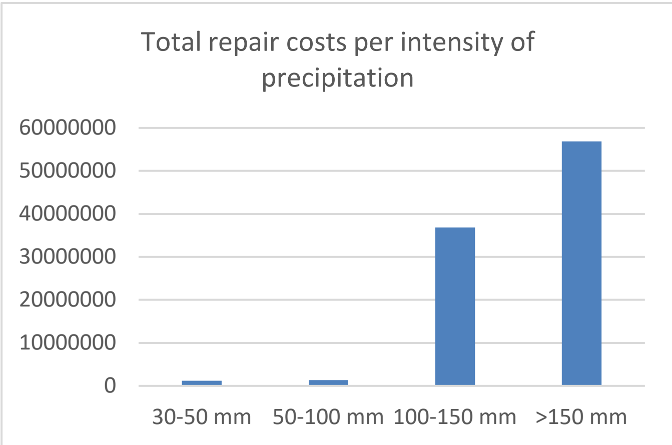

Figure 17: Total repair costs - intensity of precipitation

22. The limited data show that majority of incidents have been caused by intensity of precipitation between 30-50 mm followed by 50-100 mm and over 100 mm per day. At the same time, it is the intensity of 100-150 mm and above 150 mm per day, as shown in figure 17 that led to more significant cost of damage.

23. For type of damage per intensity of precipitation, these data have been provided for 151 incidents and are shown in Figure 18.

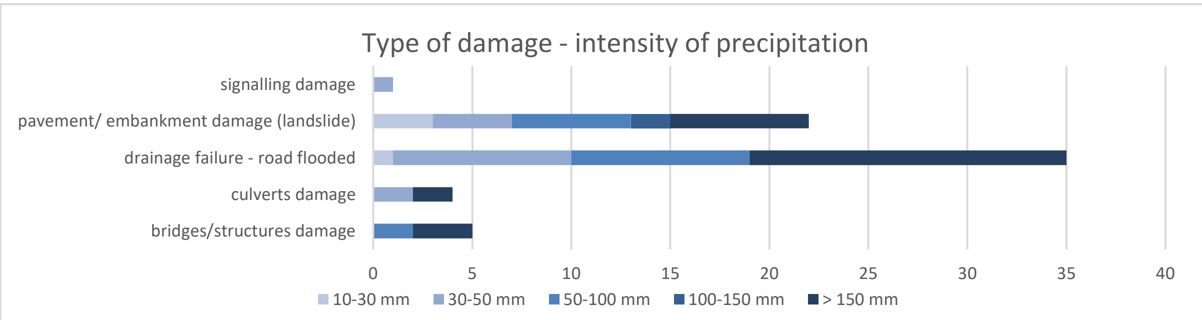

Figure 18: Type of damage - intensity of precipitation

24. As the data show, culvert and bridge damages occurred at higher precipitation intensity.

25. For type of disruption per intensity of precipitation, these data have been provided for 151 incidents and are illustrated in figure 19.

26. As the data show, traffic diversions (both specific to some group of vehicles and general) have been almost entirely caused by precipitation with an intensity under 50 mm per day.

27. Instead, long-term closures and traffic delays are also attributable to heavier precipitation, particularly the ones with an intensity higher than 150 mm per day.

28. As for rail, the longer disruption was caused by heavy precipitation. As shown in Figure 20, and based on data for 151 incidents, the precipitation with an intensity higher than 100 mm per day caused the majority of disruptions lasting between 1-3 days or above 3 days. The data also show that long-lasting disruptions may be also caused by low-intensity events.

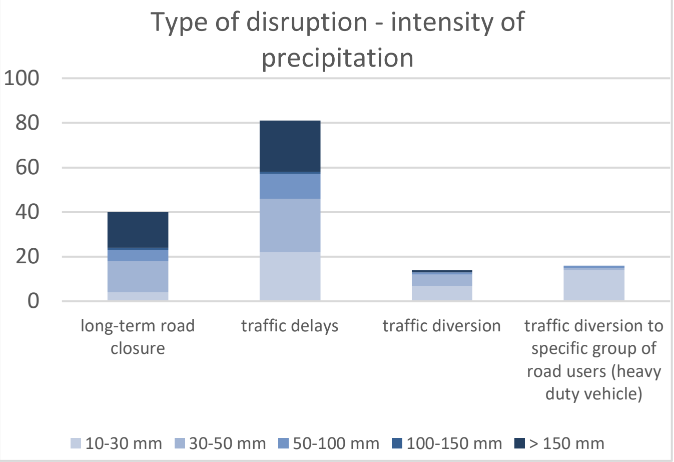

Figure 19: Type of disruption - intensity of precipitation

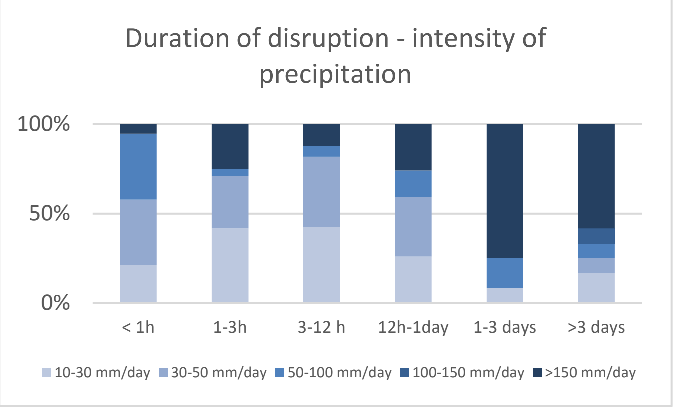

Figure 20: Duration of disruption - intensity of precipitation

29. Finally, figure 21 shows the average repair costs per duration of disruption for the incidents reported. The costs become significant if the disruption lasts longer than 12h.

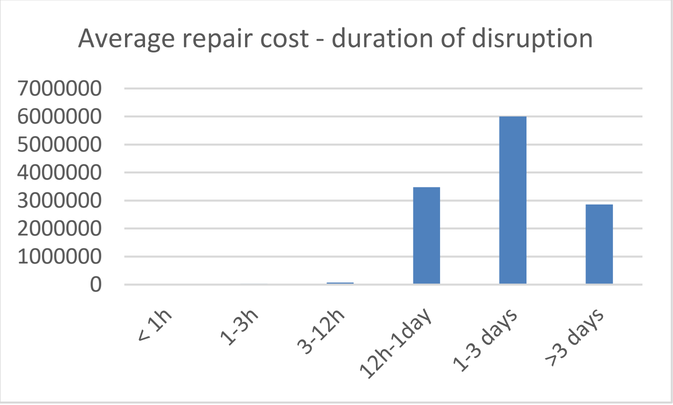

Figure 21: Average repair cost - duration of disruption

B. Caused by heatwaves

30. Altogether, there have been only 43 incidents reported on road disruption caused by heatwaves.

31. The repair costs per temperature ranges have been reported for 6 incidents only, of which 5 due to temperature ranging between 32 and 43 degrees Celsius and one in the range between 25 and 32 degrees Celsius. The average repair cost associated with the higher range equalled to Euro 752 185, while the only incident in the other range caused Euro 6 493.2 in damage.

32. Only in 3 cases the type of damage is associated with the temperature ranges: one case of "thermal pavement loading and degradation" has been registered both with temperature between 25 and 32 degrees Celsius, and 32 and 43 degrees Celsius; and one "asphalt rutting" has been reported for temperature between 32 and 43 °C.

33. For type of disruption per temperature ranges, these data have been reported for 8 incidents as shown in figure 22. One traffic delay has been registered in a day with temperature between 25 and 32 degrees Celsius; two traffic delays and five traffic diversions have been caused by temperature between 32 and 43 degrees Celsius.

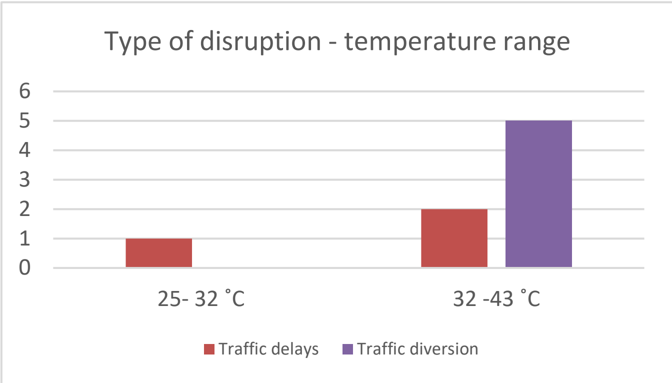

Figure 22: Type of disruption – temperature range

34. Finally, for duration of disruption per temperature range, these data have been reported for just 9 incidents as shown in figure 23. Most of the disruption lasted between 3 and 12 hours, yet the data are not representative to draw any conclusions.

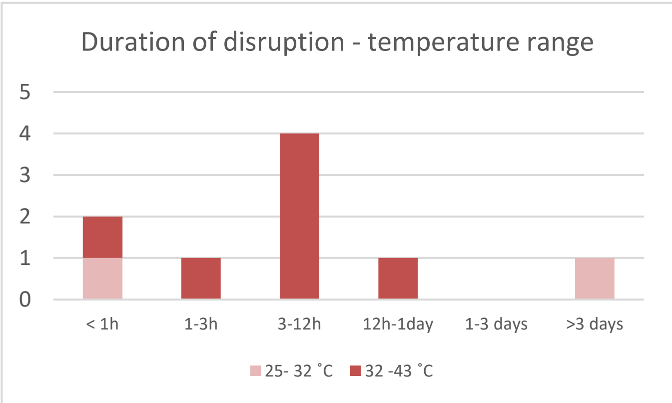

Figure 23: Duration of disruption - temperature range