



Sustainability And Resilience for Infrastructure and Logistics networks

## D 1.3 Strategies for improving resilience through participatory stakeholder practices – Delphi survey results

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## Executive summary

Climate change and directly human-driven disruptions (such as cyberattacks or terrorism) can have major consequences not only for people and safety but also for the infrastructure and transport networks, and thus affect many different stakeholders and actors in society as part of supply chains. This in the end have consequences for different end users. Disruptions on infrastructure and transport networks affect logistics and transport companies directly, but they also affect those dependent on goods and services in society, from municipalities and counties to businesses in the agriculture sector, grocery stores, hospitals, and those working in the knowledge producing sector. This deliverable is an effort to understand the severity of disruptions on the daily work of these organisations and authorities and how they deal and mitigate such disruptions through different strategies. The task is part of Work package (WP) 1 “Co-Creation of Scenario Cases and Sustainability and Resilience Evaluation Framework”, and task 1.3. “Identification of challenges, requirements, and future expectations through participatory foresight of stakeholders” as such taking the views and perspectives of different types of users of the transport system into consideration. These results will be used in dialogue with relevant stakeholders related to each of the three main scenario areas of the project: Regional (Mantua, Italy,) National (Iberian Peninsula) and EU-level, as part of the next step of WP1, task 1.4.

Applying a mixed method approach, by building on semi-structured interviews focused on three scenario areas of the project (Mantua region in Italy, Iberian Peninsula, and the EU) and construction of an online survey in two rounds using the participatory foresight method Delphi, as well as a separate survey targeted towards researchers and consultants, the goals is to reach a wide population of those affected by disruptions and who are knowledgeable on the subject.

The online survey focuses on two main topics covered in the survey(s) and of relevance to this deliverable: 1) How much disruptions have affected one's daily work, including a list of relevant disruptions procured throughout the start of the project and found through literature and the semi-structure interviews, and 2) How available certain handling strategies have been during or after a disruption. However, the survey also asked about the consequences of disruptions.

Of the respondents answering to the online surveys, findings indicate "human" driven disruptions to have a large effect on this sample's daily work, including health emergencies, war, and regulatory changes caused by such events. However, climate change driven disruptions such as extreme weather also had a notable high effect. Of the disruptions the respondents had most experience with, the consequences with highest severity were rising costs, delays or increased travel times, as well as bottlenecks in transport systems, which is not surprising considering a large part of the sample have transport as part of their daily work. The survey results confirm several of the findings from the initial interviews related to the project scenarios.

Regarding available handling strategies to deal with disruptions it is clear that more informal strategies are most prevalent, such as internal dialogue and adapting strategies as one goes. The resilience factors identified in the surveys, that are shown to be minimising the consequences of disruptive events, visibility, collaboration, flexibility and redundancy are also shown to be closely connected to these informal strategies. E.g., sudden major disruptions, such as COVID\_19 is an example showing the need for flexibility of organisations.

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## List of Acronyms

Acronym	Definition
GDPR	General data protection regulation
AHP	Analytic Hierarchy Process
LSP	Logistic service provider

# 1. Introduction

## 1.1. Background

This deliverable focuses on strategies for improving resilience in the face of disruptions that affect infrastructure- and transport networks. As such, it is the handling and mitigation strategies that organisations experience when disruptions hit which is the core focus of the deliverable. These strategies range from climate related disruptions such as avalanches and wildfires to human induced disruptions affecting transport and infrastructure networks, and are partly derived from the SARIL project's main disruptions scenarios (SARIL Project, 2023). Flooding and cyberattacks in the Mantua region in Italy, climate change hazards such as extreme weather on the Iberian Peninsula, and pandemic and war at the EU-level.

## 1.2. Hopes and Aims for the Use of the Survey

The deliverable is part of the task (1.3.) *Identification of challenges, requirements, and future expectations through participatory foresight of stakeholders*. To reach and get input from organisations, the task uses among others a Delphi survey foresight method approach based on an online questionnaire survey, to reach respondents. Disruptions on infrastructure and transport networks affect logistics and transport companies directly, but they also affect those dependent on goods and services in society, from municipalities and counties to businesses in the agriculture sector, grocery stores, hospitals and more. Thus, it has been important to include a large variety of actors in answering the survey.

The Delphi survey method provides more interactive contribution from the participants compared to a typical survey. This survey has been applied in two rounds, where the first round focuses on detection of disruptive events, their consequence and uncertainties, handling strategies, future expected disruptions and their potential impact among different stakeholder groups. The second round of the survey summarizes results and feeds them back to the respondents of the first survey round to achieve consensus or to find where the largest dissensus is. Further, the second round of results are used to give input on new questions and categories. There was also sent a separate survey to reach researchers and consultants specifically. This deliverable also gives a summary of the findings of the scenario descriptions developed in task 1.1. of the project (SARIL Project, 2023) (*Scenario cases: lessons learnt and current measures taken by the logistics sector/policy makers*) which provided input on what to ask in the survey.

The main goal of this deliverable is to show the scope and variety of disruptions that are affecting organisations, and the handling- and mitigation strategies they apply. This can give us an understanding of what could contribute to overall improved resilience, not only of transport stakeholders, goods owners and other organisations, but of the infrastructure- and transport system overall.



## 2. Method

In the next sub-sections, the methods of the task of this deliverable will be described, e.g., use of stakeholder inclusion method, semi-structured interviews and the survey approach as part of participatory foresight. As argued by Kaivo-oja (2017) there are arguments for so called future oriented technology analysis studies to adopt mixed methods and triangulation, so not to use only one method or source of data in the study of social phenomena. The general approach of answering to this part of the project is explorative in design, including a data driven approach, e.g., what are the actual perspectives and input from the stakeholders, as well as a theory or scientific literature driven approach. This can also be referred to as an inductive-deductive methodology in the data analysis, where inductive implies "bottom up", while more theoretical, or scientific driven data analysis, is more "top down". Further, doing both interviews and a survey questionnaire data gathering, contributes to an integration between qualitative and quantitative methods (Proudfoot, 2023). As the interviews were done first, they served to develop and confirm which questions and question categories to include for some of the topics in the survey, while the survey served as a way to check if some topics in the interviews also were relevant for a larger and or different audience.

### 2.1. Targeted Stakeholders

In this work, targeted stakeholder are actors involved with infrastructure and logistics network directly, which is the main focus of the SARIL project, and other stakeholders indirectly affected by disruptions in this network, which is a much wider target population.

The infrastructure and logistics network consists mainly of (1) data flow and cargo infrastructure (2) and the supply chain (McKinnon, 2023; Memari et al., 2016) and actors involved in this network who depend on a well-functioning transport system. In this chapter the understanding of roles and types of stakeholders affected by disruptions in infrastructure and logistics networks is elaborated. Figure 1 presents the public sector representing governance, policy and regulation (on blue background) framing and influencing the transportation and logistics infrastructure (in pink) and the supply chain (in green). The infrastructure serves as an enabler and premise for both production, logistics, transport, terminal handling, and distribution and is often a mix of public and private actors, while the actors in the supply chain are usually private entities. However, private actors in the transportation infrastructure and among terminal operators occur.

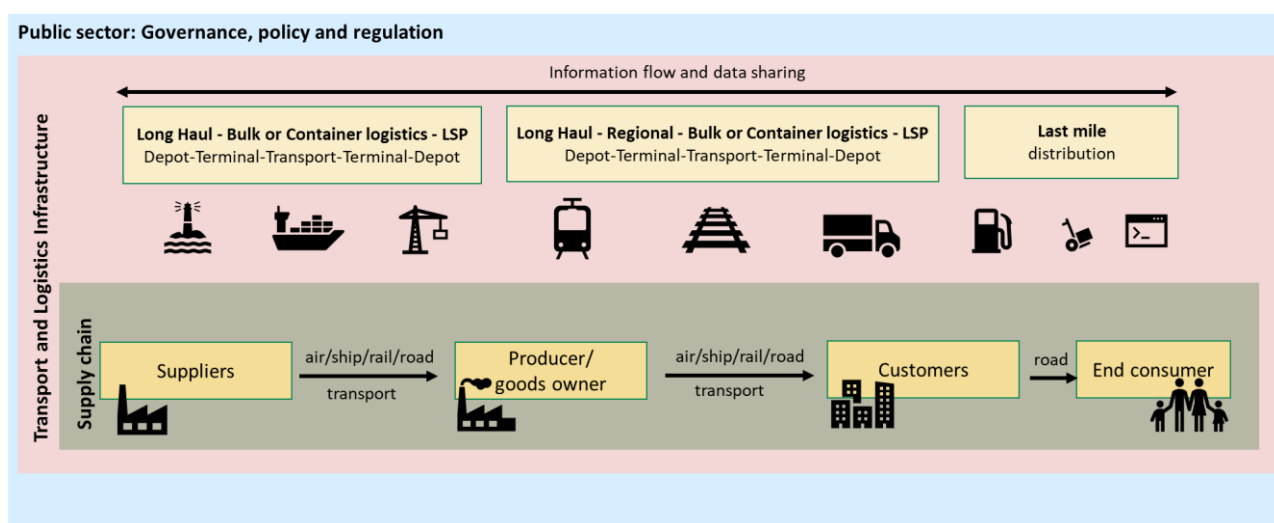


Figure 1: An illustration of the infrastructure and logistics network.

In addition to the cargo flow there is an information and data flow between the actors in the network. The information flow builds potential for data sharing horizontally and vertically within the network (McKinnon, 2023).

In SARIL a mapping of public and private actors and their role in the network has been done, covering infrastructure owners (port authorities, terminals, road and bridges) and logistics actors (freight forwarders, port operators, logistic service providers). The list of stakeholders that were interviewed in the first part of the study was developed by the project partners and included both SARIL project partners and non-project stakeholders who agreed to participate in the research. The list consisted of 59 stakeholders, including:

- The business community.
- Decision makers and public authorities.
- Technology providers.
- Others.

An invitation to interview was sent to all stakeholders, 30 of whom agreed to be interviewed.

Type of stakeholder	Total
Regional and local authorities	4
National authority	1
Workers association -representing truck drivers	1
Logistic operator for port, terminal, rail (public or private)	8
Logistic service provider or forwarder	4
Infrastructure maintenance for road, rail or waterway (private or public)	5
Company dependent on deliveries or producer	7
<b>Total interviewed</b>	<b>30</b>

Table 1: Types of stakeholders interviewed

For the survey, the target population was larger and also included stakeholders from the supply chain (green area of Figure 1), who are likely affected, such as goods owners that do not necessarily work with transport but who are dependent on transport and a functioning infrastructure and logistics network. Table 2 below summarises the stakeholder types reached out to for the survey(s) and where direct email addresses were available:

Main types	Subtypes
Public authorities Policy makers	International National Regional Local
Private actors	Logistics service providers (LSP) Terminal operators (port, rail) Technology providers Shippers Goods owners
Private/public	Infrastructure maintenance and operators Receivers of cargo, goods owners Workers association
Knowledge production	Researchers Consultants

Table 2: Stakeholder types reached in survey(s).

## 2.2. Semi-structured Interviews

The methodology for the first step of understanding stakeholders' views and perspectives', is a qualitative semi-structured interview method. The interview is a method for exploring and learning from the perspectives of actors and stakeholders who are the bearers of a challenge or solution. As such, the method is not about learning facts or truth per se, but about locating important issues for these people or actors. Moreover, what can be learned from the semi-structured approach can be seen as an approach to knowledge creation more than an approach to knowledge accumulation, as the questions may lead the interviewee to think outside the box or about events that had not previously occurred to them. For this particular purpose, semi-structured interviews are particularly good for understanding disruptions, both their consequences and how to mitigate them. Although there are many approaches to interviewing (e.g., Fontana, A. & Frey, J. H., 2005) in this project the interviews were conducted face-to-face or in online meetings and usually in the language of the stakeholder.

The number of interviews in each scenario varied depending on the focus of the scenario. The total number of interviews for each scenario was: EU-wide scenario: 7 interviews, national scenario: 13 interviews, regional scenario: 10 interviews. This process has also been documented partly elsewhere (Waldmann, M. et al., 2024)

The semi-structured interview study was conducted with 19 questions guiding the conversation towards:

- The identification of disruptions faced by survey participants, especially focusing on those related to transport and logistic networks.
- Available and used data sources in the context of anticipating and dealing with disruptions.
- Preventive measures used in companies/organisations, lessons learned from the disruptions experienced in the context of their own organisation as well as the logistics market as a whole.

## 2.3. Participatory Foresight with Delphi-survey – Online Questionnaire

This study has applied a particular design for the survey – a foresight process method to include stakeholders, beyond the core groups of the project. To engage stakeholders in a foresight process is termed participatory foresight, as it includes all social actors who might be relevant or knowledgeable on the topic (Kunseler et al., 2015, p. 2). Participatory foresight in this project is applied to reach "the broader inclusion of diverse participants (experts, citizens, stakeholders or nongovernmental activists) and their perspectives has been seriously considered as a means to expand the visibility of the future and promote firmer engagement with it" (Nikolova, 2013, page 1). Participatory foresight can identify how the actions we choose today may affect possible and desired change in the future (Borch et al., 2013) which is why it is an especially relevant methodology for disruptions.

For this part of the project, the foresight method Delphi survey was applied. Delphi survey methodology dates far back and is characterised as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem (Linstone, H. A. & Turoff, M., 1975). A Delphi survey is typically done in two rounds, giving the stakeholders the chance to adjust their input according to the other stakeholders' views following the results from the first round. Delphi surveys have also been done in four rounds when enquiring about shared autonomous vehicles (Merfeld et al., 2019). Delphi approaches have proven particularly helpful in contributing to risk analyses for supply chain security (e.g., Markmann et al., 2013) by giving input on identifying and quantifying risks, by analysing stakeholder perceptions and

by stimulating a more global communication process, which is of particular interest in this project. Further the method can identify unknown factors and uncertainties that could be drivers or barriers to development. The further use of findings from the survey will be applied in the scenario planning of task 1.4.

In this study, it was decided to conduct a simple version of a Delphi survey, with two rounds, and online, to assure many relevant respondents were reached. The goals for the first round: To widen the "horizon" – e.g., what types of disruptions have affected stakeholders, what different types of impacts the disruptions had, and what are barriers to handling them, along with several questions on challenges at the organisational level. The latter was especially a topic included on behalf of the sister project ReMuNet (ReMuNet, 2023). The different topics of the complete survey will be presented in section 2.4.

The goal for the second round: Adding new questions based on the findings in the first round and indicators/answer categories provided by the respondents, to give the same respondents the chance to reconsider their viewpoints – when presented with the aggregated answers from first round. In a parallel survey round, a set of revised questions were added, specifically targeted towards experts such as researchers and consultants who were asked to review indicator lists for resilience.

The overall goals of SARIL are to: “Develop holistic methodologies and tools for enabling infrastructure managers to assess the resilience of logistics networks and improve them to ensure appropriate ‘green resilience’ when expanding the infrastructure. It will also provide logistics stakeholders with information about disruptions to assist in making the right decisions about moving cargo, evaluating, and developing new mitigation measures and employing simulations to predict their effectiveness.” However, the EU is also funding another project working with similar topics, ReMuNet “Pioneering resilient and adaptive multimodal transport networks” (ReMuNet, 2023). “ReMuNet strives to promote event-driven intermodal transportation across European rail, road, and inland waterways, bolstering supply chain resilience in the face of disruptions. The project's objective is to develop a digital solution that can promptly detect and alert to disruptive events, evaluate their effects on various transport routes through data sharing among logistics stakeholders, and enhance route planning resilience by suggesting predefined, multimodal alternatives.” While SARIL aims at an understanding and modelling of multimodal logistics at a holistic perspective considering different geographical scales, ReMuNet focusses on the development of standards for disruption handling and a collaborative platform which should encourage data sharing between logistics stakeholder to improve robustness and efficiency of transport processes.

In autumn 2023, it was decided, after some initial meetings, that SARIL would collaborate with ReMuNet to merge the two projects questionnaire surveys, both considering the similar topics but also to enable to reach a wider network of respondents. This was suggested by the EU-officer of SARIL and agreed by the project leaders in SARIL and ReMuNet, if the researchers would see the benefit. A series of meetings followed with scoping and understanding the needs of the two projects where it was finally decided to go ahead with the collaboration. Both projects had already used time to develop their survey questions so a direct merging of both surveys would create too many questions. The solution was to go through the questions, internally first on which questions were important, less important and which could be considered cut, for the benefit of a joint survey following a traffic light system. Both projects shared these suggestions with each other, before a couple of meetings were used to finally determine which questions to keep and which to cut. The projects also agreed that only round 1 would be the joint part, as only SARIL had interest in the second round to fulfil the plans from the proposal of the project. The length of the survey still demanded to set off around 20-25 minutes to answer it for respondents in the end, depending on which stakeholder one represented. It was not

possible to cut more, as that would diminish the goal of both the deliverables and papers planned in the two projects. Following the decision of a joint survey, SINTEF who is data controller of the survey result collection (to abide by GDPR) was in charge of putting the questions into the final survey tool and also take care of translations and other dimensions related to the preparation for send out. An elaboration on send-out and outreach can be found in section 2.5. The next section covers the reasoning behind the survey topics.

The tools chosen for the Delphi survey rounds were Welphi. And for the researchers' and consultants' survey we used Netigate. More information on these tools can be found in the following links: [Welphi](#) and [Netigate](#).

## 2.4. Categories of Survey Questions

As mentioned previously, both a data- and theory driven approach was used to arrive at the actual survey questions. The relevant findings of the interview results which will be described in section 3, gave input on the development of the survey questions, as well as scientific literature, and are included in the reasoning column in Table 3. The main structure of the survey questions was inspired by Garmabaki et al. (2021) where the main aim was to qualitatively identify and assess the impact of climate change on railway infrastructure as well as risks and consequences connected to this.

Category	Reasoning	Example
<b>Demographics</b>	Basic understanding of the survey respondents	Role in the organization, knowledge of TEN-T corridors, ...
<b>Value contribution</b>	Role in the logistics industry and position in the value chain	Relevant modes of transportation, IT systems in use, ...
<b>Challenges</b>	Identifying the most important challenges and relevance of different categories of challenges	Cost challenges, regulatory challenges, infrastructure challenges, ...
<b>Disruptions</b>	Assess the impact of disruptions on the respondents' organisation. Some of disruption framings and consequences were included in answer alternatives mentioned in interviews. Also inspired by climate risk parameters (Wang et al., 2019)	Occurrence of disruptions in the past 5 years, e.g. demonstrations, strikes, wildfires, flooding etc., severity of consequences, and types of consequences, such as delays
<b>Handling strategies</b>	Understand how organisations deal with disruptions. Some of the handling strategies included in survey questions were mentioned in interviews.	Formalized system to handle disruptions, handling strategies, ...
<b>Environmental aspects</b>	Environmental impact of handling strategies. Included also because of relevance to WP4 on impact assessment.	Relevant aspects when considering handling strategies/solutions, ...
<b>Resilience</b>	Learn about the respondent's organisational resilience (Especially relevant for task 1.2. of the project).	Importance of attributes to organizational resilience, ...
<b>Possible solution</b>	Get a basic understanding of critical requirements for a solution	Requirements for a possible solution, ...

Table 3: Categories of survey questions<sup>1</sup>

<sup>1</sup> Not all respondents got all questions as there was a filter included. E.g. the number and selection of questions depends on the stakeholder's role in the multimodal logistics process and previous answers. Some of the results from these questions are not included in this deliverable but will be used in other parts of the project dissemination.

## 2.5. Stakeholder Outreach Approach and Dissemination of Survey

The strategy for reaching relevant stakeholders and respondents to the survey has been twofold: 1) Reaching out directly by creating stakeholder lists together with partners in the project for different types of main stakeholders, and 2) dissemination widely in channels such as LinkedIn, both in groups and posts through project sites and personal accounts, on websites, and through newsletters.

The direct outreach used a list of potential survey recipients created by the project partners. The list of potential survey recipients consisted of 127 potential subjects able to participate in the extended online survey.

For reaching out directly several approaches were used depending on the closeness of the contact:

- One-to-one email invitations.
- Group email.
- Blind copy emails.

To avoid language barriers and to make it as easy as possible for respondents to participate in the survey, the survey and the invitation letter were translated into six languages: Spanish, Portuguese, Norwegian, Polish, Italian and German. Depending on the geographical location of the respondent, the survey was automatically translated into the appropriate language version for the region in the browser upon opening the survey.

The objective of the survey was to reach respondents from different levels of infrastructure and logistics networks, including those depending on transport, which is why dissemination through social media and industry portals was conducted in collaboration with the ReMuNet project. During the preparation of the survey, an information campaign was run announcing the projects' activities and announcing the survey. At the time the survey was published, extensive dissemination activities had been carried out, such as:

- Publications encouraging participation in the survey on the LinkedIn channel of the SARIL project.
- Publicity to encourage participation in the survey on the ReMuNet project profile.
- Publications encouraging participation in the survey on the profiles of members of the project team.
- Publication of articles on branch portals [intermodalnews.pl](http://intermodalnews.pl), [intermodalnews.eu](http://intermodalnews.eu), and the Inside Logistics magazine.
- Publication of an article on the website or newsletter and LinkedIn profiles of some of the project partners – e.g., SINTEF.NO, L-PIT, Rangel.
- Organisation of a webinar by ALICE during which participation in the survey was encouraged.

Activities were carried out to spread the word as widely as possible about the survey being conducted and to encourage potential respondents to take part in the survey. The invitation letter also contained an announcement of the possibility to win small sum gift cards, sponsored by two of the logistics partners SARIL, to encourage people to use of their time for responding.

## 2.6. Limitations of Method and Survey Tool

Despite the efforts of getting people to respond to the survey, the response was low (see below). The main limitation of applying a two-round survey is one of stakeholder fatigue. With two rounds, there

is extra time consumption for each respondent, which could be the main reason for the even lower response in round two.

One potential cause of the low response may have been the need to register and login. This was needed to be able to connect responses between round one and round two. However, the system for registering was simple, and done with only a few clicks, and no need to confirm e-mail address.

Further, the survey became very long, especially due to collaboration with the sister project ReMuNet. The decision to do so was still the right one. The topics and research interests in the two projects are similar, and the projects reached much larger networks of contacts. But the "cost" in time for each respondent is that I took a long time to respond, as the survey became longer.

Further, the tool itself might have been a barrier itself. Certain functions in the tool were not optimal. For example, one had to click yes or no on each sub-question for some categories, when it should have been a possibility to just choose a category with one single click. The choice of this tool, had to do with the Delphi-functionalities needed, such as the possibility to add new categories to questions, with the "Add indicator" button. And it was the only one obliging to GDPR regulation within its category. For this reason, the tool was used despite its deficiencies.



### 3. Results of the Interviews

The European freight transport network has experienced major disruptions in recent years due to the global crises mainly connected to COVID-19 pandemic, war and climate crisis. Stakeholders interviewed in the first phase of the SARIL project highlighted several problems, due both to human and climatic factors, that they have had to face in recent years.

During the interviews, special attention was given to the impact of the COVID-19 pandemic, which affected both global and local logistics chains. Respondents also noted that since 2020, transport chains have been disrupted not only by the pandemic, but also by accidents and incidents caused by human acts.

In the local and national scenarios, significant human factor impacts were caused by the pandemic and strikes by logistics workers in Europe. However, the main emphasis in these scenarios was placed by respondents on the impact of climatic and environmental factors on logistics networks, through the impact of environmental factors on the disruption of transport infrastructure.

The interviews identify disruptions to logistics networks caused by the human factor, i.e. those disruptions that are directly influenced by human actions or decisions. The effects of the COVID-19 pandemic, the blockade of the Suez Canal and military action in Ukraine were identified as the most significant human factor-induced disruptions significantly affecting logistics networks. Among these root causes, specific disruptions that have a significant impact on the functioning of nodes and links in the logistics networks can also be singled out, such as:

- Sudden reduction of the inflow of raw materials and preliminary products.
- Increase in transport rates.
- Sudden drop in transport rates.
- Introduction of lockdowns.
- Problems with access to transshipment infrastructure.
- Lack of available transport infrastructure.
- Congestion at ports and transshipment terminals.
- Staff strike.
- Sudden increase in volume.
- Sudden drop in volume.
- Decrease in staff availability, including shortage of drivers.
- Increase in energy costs, including fuel costs.
- Reduced capacity of transport routes - especially rail lines.

The above disruptions were identified as significant, mainly by those working operationally in the transport and logistics network, such as manufacturers, logistics operators, terminal operators and freight forwarders. These actors experienced the widespread impact of geopolitics on their daily operations.

For infrastructure managers, operating mainly in the local and national scenarios, experienced a problem resulting from disruptions related to the COVID-19 pandemic. In the national and regional scenarios, furthermore, those interviewed pointed to disruptions resulting from climatic influences such as:

- Forest fires.
- Storms.



- Snowstorms.
- Downpours.
- Flooding.
- Icing on roads.
- Landslides.
- Droughts.
- Earthquakes.

Disruptions related to climate impacts have not been the main area of interest for operators involved in the global logistics chains, even though the local perspective and impact of climatic factors can also affect the operation of the logistics networks in which they operate. Table 4 shows the identified main disruptions that have affected the business over the past five years.

Disruption	Scenario		
	Regional	National	EU/ Global
Pandemic	2	13	7
War			3
Suez Canal blockage			2
Lack of access to raw materials			1
Increase of transport rates			4
Decrease of transport rates			2
Lockdowns			2
Lack of infrastructure capacity			2
Lack of transport equipment			5
Congestion in ports			5
Strikes	1	3	0
Decrease of cargo volume			5
Increase of cargo volume			5
Driver shortage	1		3
Increase of energy costs (energy, fuel)			5
Reduced capacity of railways			3
Fires in port	0	2	
Forest fires	5	8	
Sea storms		1	
Snowfall		4	
Heavy rains	1	1	
Flooding	8	4	
Ice roads		4	
Landslides	6		
Droughts	1		
Earthquake	6	1	
Total	31	41	54

Table 4: Disturbances identified by the interview respondents in regional, national, and global/European (EU) scenarios

### 3.1. Regional Scenario

In the regional scenario, interviews were conducted with representatives of transport and logistics infrastructure and supply chain actors, such as:

- Authorities.
- Workers association representing truck drivers.
- Logistic operator for port, terminal, rail (public or private).
- Logistic service provider or forwarder.
- Infrastructure maintenance for road, rail or waterway (private or public).
- Company dependent on deliveries or producer.

The regional scenario in the Mantua region focuses on local disruptions, which is reflected in the needs of the stakeholders interviewed. The main focus of interviewees is on climate-related hazards, mainly flooding, as indicated in Table 4. Landslides, earthquakes and forest fires were also identified by more than half of the respondents as important risks affecting the operation of logistics networks for their companies. Threats related to natural factors such as flooding affecting both the state of the transport infrastructure and delays and further disruptions in the system of logistics processes. Interviewees indicate that they have seen a recent increase in the frequency of extreme natural events in recent years.

#### **Handling strategies**

The interview also looked at how the logistics operators dealt with the disruptions that took place and what lessons they learned for the future. In terms of dealing with disruptions, respondents indicated that the most important thing for them was to guarantee safety and restore safe transport conditions.

Companies said that during transport disruptions caused by extreme natural events, such as floods, they aim to ensure safety on all modes of transport. The priority during these events is to get cargo safely to its destination while minimising any delays and, above all, the safety of people. During these events, they provide alternative transport methods and routes, including using road transport. The authorities aim to ensure and prioritise the continuity of transport services and the safety of users. They coordinate these activities with other territorial entities such as regional and municipal authorities. During these events, it is their responsibility to ensure the safety and restoration of transport conditions. In such circumstances, they have to face two main consequences: the immediate and direct effects of extreme events, requiring emergency interventions to ensure safety, and the long-term effects of natural disruptions, which require more time to restore previous transport standards. Their priority is to reach the affected areas as quickly as possible to ensure safety and restore protection, despite the costs involved. In these stages, assessing infrastructure damage and identifying critical points in the transport network is crucial. Having data related to traffic flows, affected routes, areas affected by specific damaged infrastructure elements and intervention models for specific damage would benefit them.

During disruptions and cyberattacks, some of the entities interviewed are tasked with ensuring that the core functions or services that the entity offers to the country can return to full operation as quickly as possible, while ensuring that a malicious attacker is fully removed and cannot launch the same attack again. They have developed internal tools capable of detecting compromised resources, services/devices and misconfigurations for an entity belonging to their constituency.

## Conclusion and challenges

Based on the experience of recent years and previous disruptions, interviewees see the need for changes in the processes of infrastructure maintenance and communication with territorial authorities. The interviewee noted that there is a need for collective cooperation between transport companies and territorial authorities during disruptions caused by extreme natural events. Some stakeholders highlighted that the data they currently use is becoming outdated due to changes in traffic demand. They believe that having better weather forecasts and a better predictive mathematical model would be very beneficial. Currently, many companies do not have an internal plan to deal with such events.

The interviewees suggest involving more competences and territorial authorities during such events. They recommend investing in prevention plans and training activities. In their view, it may be helpful to define the critical points that may be affected by these extreme events and to secure them with appropriate infrastructure.

With regard to planning alternative routes, the interviewee noted that during such incidents, the road alternatives suggested by navigation systems are sometimes impractical for larger trucks. Restrictions due to street geometry can also cause trucks to get stuck on these routes. They ask for a more sensible navigation system that offers viable alternatives for truck drivers. In addition, they ask for more detailed traffic data.

Interviewees also indicated that reaction time is a key aspect during this disruption. For them, it will be beneficial to have a platform to help manage alternatives more efficiently. They are asking for more precise meteorological data, as well as data on transport flows.

### 3.2. National Scenario

In the national scenario, interviews were conducted with representatives of transport and logistics infrastructure and supply chain actors, such as:

- Authorities.
- Workers association -representing truck drivers.
- Logistic operator for port, terminal, rail (public or private).
- Logistic service provider or forwarder.
- Infrastructure maintenance for road, rail or waterway (private or public).
- Company dependent on deliveries or producer.

The impact of the pandemic on the activities of actors in the logistics networks is manifesting in each interview, but events due to climatic factors, and strikes by port workers and hauliers also play a large role for the actors interviewed in the national scenario (Table 4).

Interviewees indicated that they had been affected by the war and the pandemic in terms of work stoppages and material price inflation. Although ports in Spain are well prepared for the increased traffic resulting from the pandemic, infrastructure managers as well as participants in logistics chains have encountered disruptions related to the effects of the pandemic. Carrier strikes were pointed as a particular factor causing disruption in the national scenario. Around a quarter of those interviewed indicated a problem caused by strikes, and for some this was the main disruption they experienced. Interviewees noted that the freight transport sector can disrupt the entire logistics chain, as striking hauliers are, in their view, the most vulnerable link in the logistics chain.

A strong emphasis on the aspect of disruptions related to climatic factors is evident in the national scenario. Many of the actors interviewed indicate that disruptions of various kinds - fires, snowfalls, floods and icing significantly affect delays in logistics operations and the operational activities of ports and infrastructure managers. Snowfalls in particular play a major role in this.

### **Handling strategies**

In the interview it was also asked how logistics market actors handled the disruptions that occurred, and what lessons they learned for the future. In terms of coping with disruptions, the interviewees indicated that it was most crucial for them to guarantee the continuity of the service. The entities stated that in case of disruptions they use different suppliers and different transport companies that are not affected by e.g., snowstorms. The infrastructure authorities prioritise safety during disruptions, storing data on incidents and victims for at least 10 years. They apply a Safety Management System, continuous training, and risk assessment procedures.

Some of interviewed companies have prevention protocols, such as biomass management or an action plan against snow. The organisation that has experienced disruptions have established protocols and procedures for various disruptions, emphasizing the importance of communication systems, environmental protection, and collaboration with other administrations.

Noting the strong influence of climatic factors on flows in logistics networks, and their own experiences, interviewees see a strong need for authoritative sources of information regarding unforeseen events. This includes weather events as well as events such as strikes, affecting the operation of logistics networks.

To solve this situation, they need a better warning system from the administration, better planning and reaction to these events that can be anticipated, and support for this type of heavy vehicle service.

### **Conclusion and challenges**

Based on the experience of recent years and past disruptions, the interviewed actors see the need for changes in logistics processes, mainly towards the collection and analysis of data that can be used to anticipate disruptions. Past disruptions, including incidents caused by forest fires and floods, have resulted in train disruptions and passenger injuries. Future concerns include improving contingency plans, improving coordination and control to prevent disruptions.

The need for collaboration between multiple levels of logistics network participants was particularly highlighted in the needs of respondents to this scenario. Many interviewees indicated that there is a need to share information between infrastructure managers and users, and to collect and distribute weather information through a consistent alert service. At the same time, business groups are extremely cautious about sharing information, which is detrimental to the sector. Anonymised data from the primary sector is beginning to be digitised by the administration. However, there is a need for greater commitment and efficiency from both the administration and business associations. There is a need to collaborate with the administration and emergency services, to improve weather warnings to the public and centralise the official information website, and to address the challenges of work stoppages and material price inflation during war and pandemics. Interviewees indicate that there is a lack of some kind of digital tool to combine and optimise meteorological data for better action planning. On the data side, they are interested in digitalising the planning of port operations through the use of artificial intelligence. During the discussions, it was pointed out that weather-related delays during ship docking pose a major challenge. To address this, they suggest cooperation between port

authorities to negotiate more direct shipping lines with Asian ports, with the aim of minimising disruption and increasing on-time delivery of products.

### 3.3. EU Scenario

In the EU scenario, interviews were conducted with representatives of transport and logistics infrastructure and supply chain actors, such as:

- Logistics operator for port, terminal, or rail (private or public)
- Logistics service provider or forwarder
- Company dependent on deliveries or producer

In the interviews, companies identified the main disruptions that affected their operations. The companies were affected by disruptions related to the pandemic and the war. The problem for some of them was the oversupply the cargo, which was causing ports and port terminals to lock up, while there were not enough vehicles to move cargo out of the port. Further, the oversupply caused a lack of space in warehouses and transshipment points. High shipping rates during the pandemic resulted in cargo being transferred to rail on the New Silk Road instead of the sea way. Due to the war in Ukraine, companies were hit by rising fuel prices, and the complete blockage of cargo transport via the New Silk Road. The companies pointed to being affected by the pandemic in the form of sudden fluctuations in cargo volumes, a shortage of transport equipment, high transport rates and fuel price increases that have pushed up rates for road hauliers.

Rail operators were particularly affected by the sudden increase in rail volumes during the pandemic, and were significantly affected by the decline in volumes as a result of the war in Ukraine. In the event of an increase in demand for containers during the pandemic, one company responded by purchasing its own containers and making them available to customers. The rapid increase in the number of cargoes and the consequent increase in the number of trains on the tracks was also a problem. This has resulted in a reduction in rail route capacity. In addition, the energy crisis resulted in additional coal loads on the Polish and German tracks, causing a company to face many operational difficulties. High energy prices caused an increase in the carrier's operating costs. The terminal operators mainly faced problems with the availability of fuel for terminal equipment.

Aggregating the data from the interviews, it can be seen that the impact of the pandemic on the activities of actors in the logistics networks was dominant in the interviewed group. The COVID-19 pandemic manifested itself in the statements of all respondents interviewed. As shown in Table 4, many of the respondents identified the lack of transport equipment in recent years as significant, and the sudden fluctuations in cargo volume that resulted from changes in the market as a result of the pandemic. The increase of energy costs occurring after the outbreak of the war in Ukraine, was identified as a significant disruption. However, the war itself was indicated as a disruptive factor by less than half of those interviewed, which has to do with it being perceived mainly as an obstacle to transport routes, and not all the cargo routes of interviewees operate in a war-affected, or close-to-war, area. Given the low participation of producers in the interviewed group, the low impact of a factor such as access to raw materials, the reduction of which was not of direct interest to the other interviewees, is also apparent. Climatic factors such as fires, floods or droughts were not considered by those interviewed in this scenario to significantly affect their logistics chains.

## Handling strategies

The interview also asked about how logistics market actors handled the disruptions that occurred, and what lessons they learned for the future. In terms of coping with disruptions, the respondents indicated that it was most crucial for them to maintain the logistics continuity, and customer relations, which was expressed in the statements of each of the actors interviewed. It was crucial for the companies to maintain continuity of processes and deliveries, customer satisfaction and on-time delivery. To maintain continuity in the supply chain, and cooperation with trusted subcontractors - freight forwarders was essential. Securing freight slots at the rate contracted with the customer was key - the reliability of the company in relation to the customer was crucial.

In case of handling disturbances, many diversification measures have been taken, both in terms of the choice of modes of transport, services, fuel, or material suppliers. The increase in sea freight meant that rail rates on the NSR levelled off and alternative routes could be offered to customers at a similar price, which was good for the company's product diversification. Alternative transport solutions, new markets and sourcing of raw materials had to be found. The sudden increase in transport rates made it necessary to renegotiate contracts or find other outlets.

## Conclusions and challenges

Based on the experience of recent years and disruptions, the interviewed actors see the need for changes in logistical processes, mainly in the direction of broad process diversification, but also in the collection and analysis of data that can be used to predict disruptions. Based on previous experience, only one of the interviewed companies has introduced crisis management, as well as special purchasing procedures for times of crisis. There, the market situation is monitored on an ongoing basis based on forecasts of transport prices, fuel prices. The majority of companies, despite disruptions, do not analyse past data, do not introduce preventive measures and do not carry out market analyses to safeguard against future disruptions. They rely on the experience of their staff to respond to current market events, even though they think it would be useful - to know whether the actions taken were appropriate. Up until now, no one has analysed past events in terms of future use of fleet or staff and learning from past experience. Furthermore, one operator indicates that they do not introduce preventive measures because every situation is different, and it is difficult to predict disruptions at any given time.

What is missing, according to the responders is the access to data on the market, which would allow to analyse current situations of the logistics network and predict the disruptions. According to the interviewee, the problem with the data is that they are very dispersed, e.g. data in terms of the number of trains planned on a given route. Data is available but not easily, and not in one place. At present, each operator plans itself and only a few make this information available externally. The need is to easily access the forecasts of rates in road transport, prediction of rates, fuel prices, compilation of market comparisons of railway results, e.g. railway rates, market benchmark. The responders note that every shipowner lacks to publish clear information about what type of ship is sailing, and when and where it will arrive. Each shipowner publishes this on their own, but it is not transparent and structured. Also, one terminal operator notes that to maintain smooth operations, a better flow of information from shipowners about the status of containers destined for a given terminal would be useful. Shipowners have such data in their systems, but this information is not available for the other stakeholders of the logistics process. Access to them would allow for better planning of processes in a 1 or 2-month horizon.

## 4. Results from the survey(s)

The following section summarises the results from the surveys on the most relevant questions. The survey generated in total 36 respondents who answered all the survey questions in the round one of the Delphi. However, some questions had more responses, which is reflected in the  $n$  on each of the following figures and tables. The survey's first round was launched and opened on 15<sup>th</sup> of December 2023 and closed on 5<sup>th</sup> of February. Round 2 was opened on 7<sup>th</sup> of February (only to those that had completed round 1), and closed on 21<sup>st</sup> of February.

### 4.1. Description of Sample of Respondents

Figure 2 describes the proportion of responses related to the role they have in their organisation. The majority of respondents work in *management or strategy* (over 60 percent). The second largest proportion replied *Other* (approx. 20 percent).

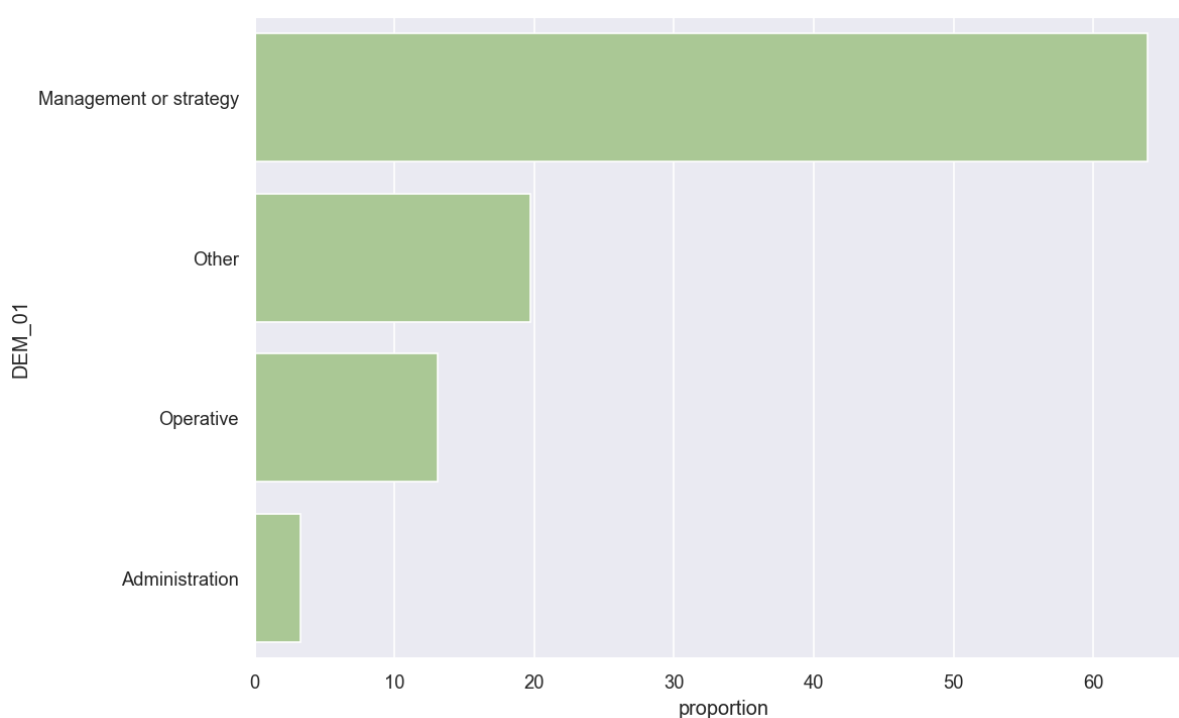


Figure 2: What is your role in the organisation/company you work for? DEM\_01.  $n = 61$

The remaining respondents answered that they worked in *Operative* or *Administration* (the smallest proportion in the sample).

The majority of respondents worked in the commercial sector (as illustrated in Figure 3) and this proportion constitute almost half of the respondents in the sample. The second largest proportion was the *public sector*. The third largest proportion was respondents working in *knowledge production*, and fourth was either and *NGO or an association*.

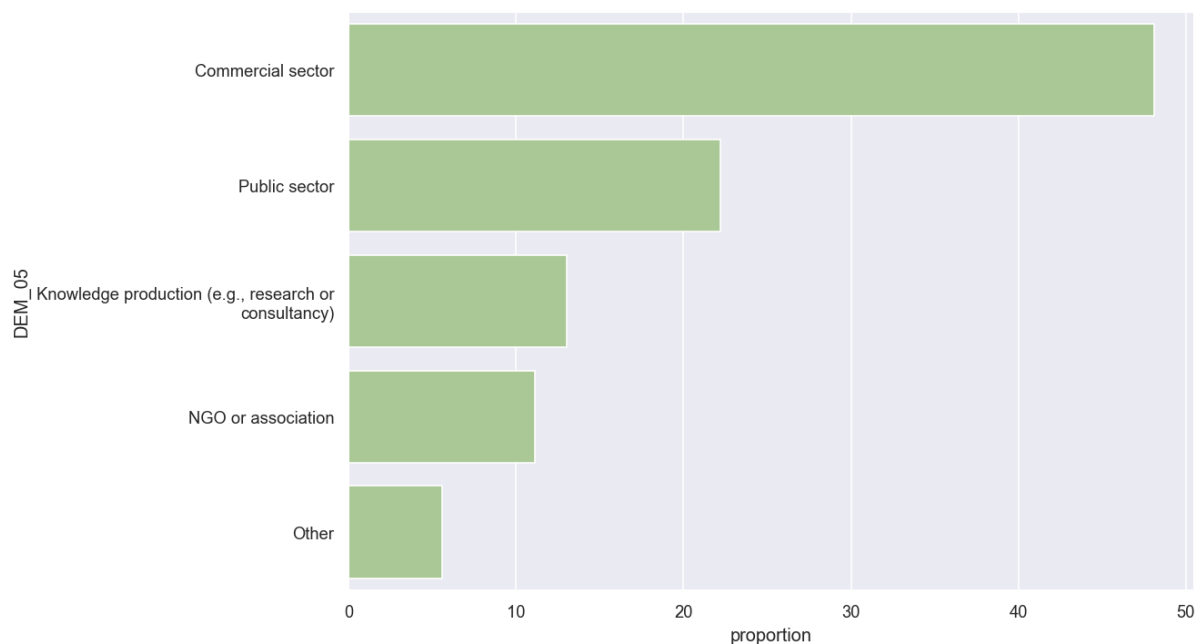


Figure 3: What main sector does your organisation/company work in? DEM\_05. n = 54

Beyond identifying the relevant sector, the respondents were also asked what the main activity of their organisation/company was. The results (proportion of each presented activity) are presented in Figure 7. The largest proportion (almost 40 percent) responded logistic service provider. The second largest proportion is tied between two groups; approximately 15 percent responded terminal operator/owner or digital logistic service provider. The lowest proportions were among primary producer, freight forwarder and infrastructure operator/owner, with proportion sizes below five percent.

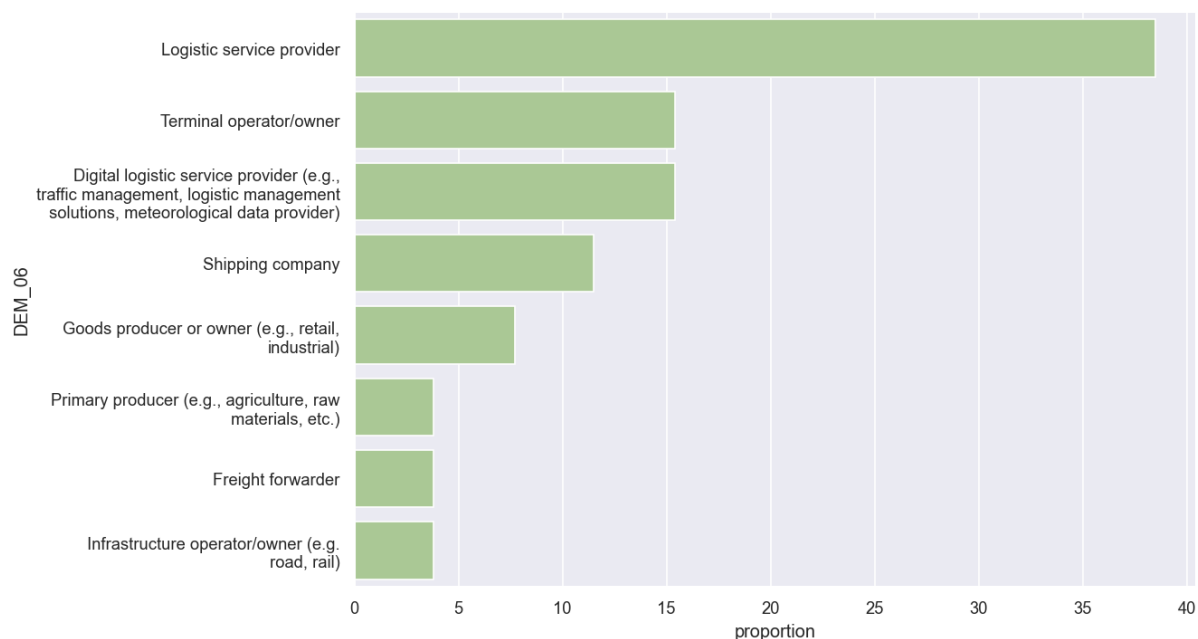


Figure 4: What is the main activity of your organisation/company? DEM\_06. n = 26

DEM\_06/*What is your main activity*, was an optional question, and quite a few respondents skipped it. Potential explanations for this can be 1) loss of interest for the survey causing drop-out and/or 2)



frustration that there is no “Other” category where respondents who could not find a fitting category could fill in their answer.

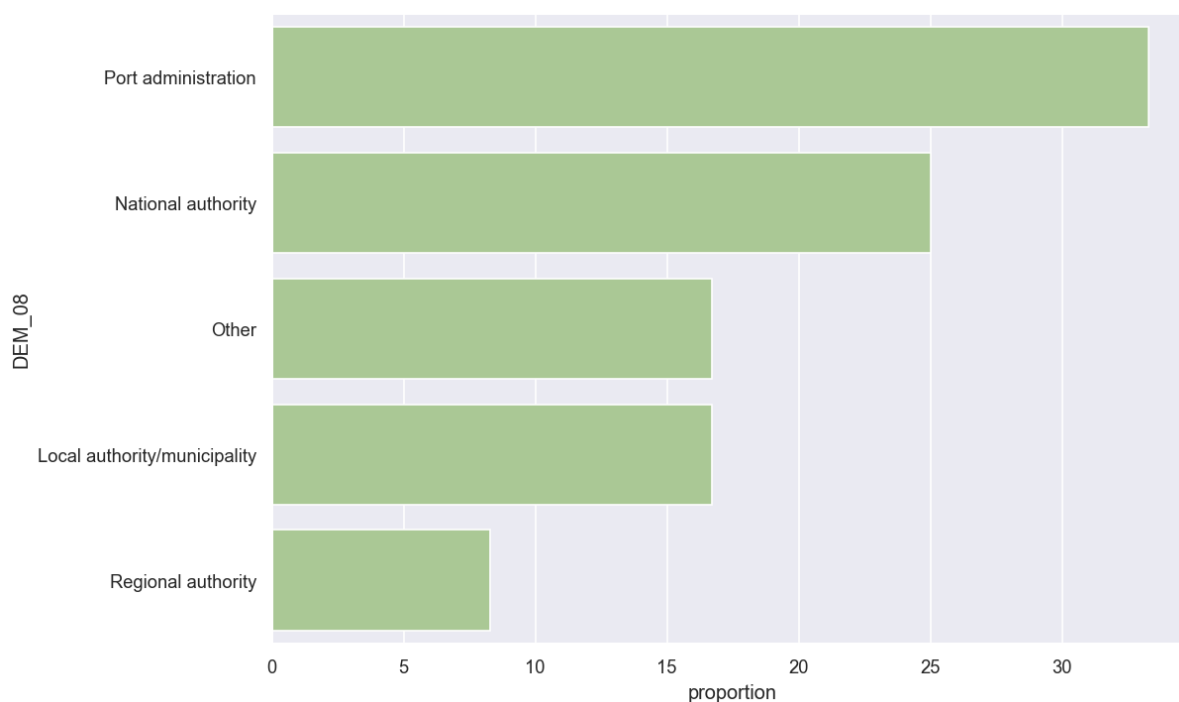


Figure 5: Please specify the type of public sector you are in. DEM\_08. n = 12.

Figure 5 presents the proportions between sector specification amongst those who answered that they worked in the public sector. The majority of respondents work in port administration. The second largest proportion is national authority. The smallest proportion of respondents worked in the regional authority.

If relevant, some respondents were asked what types of terminals they work with (illustrated in Table 5). The number of reporting respondents were low (n=4). However, all those working with terminal worked with *railway terminal*, *seaport*, *storage terminal (long term)* and *trucking terminal*. The survey reached respondents working with river port/inland port, intermodal terminal, distribution centre (last mile) and consolidation centre. No respondents reported that they worked with airport cargo terminal.

	Don't know	No	Yes
Airport cargo terminal	25	75	
Consolidation centre	25	25	50
Distribution centre (last mile)		75	25
Intermodal terminal		25	75
Railway terminal			100
Seaport			100
Storage terminal (long term)			100
Trucking terminal			100
River port/inland port		50	50

Table 5: Do you work with any of the following terminal types? If a terminal type you work with is not listed, please add it by clicking "ADD INDICATOR". n = 4. (all commercial sector)

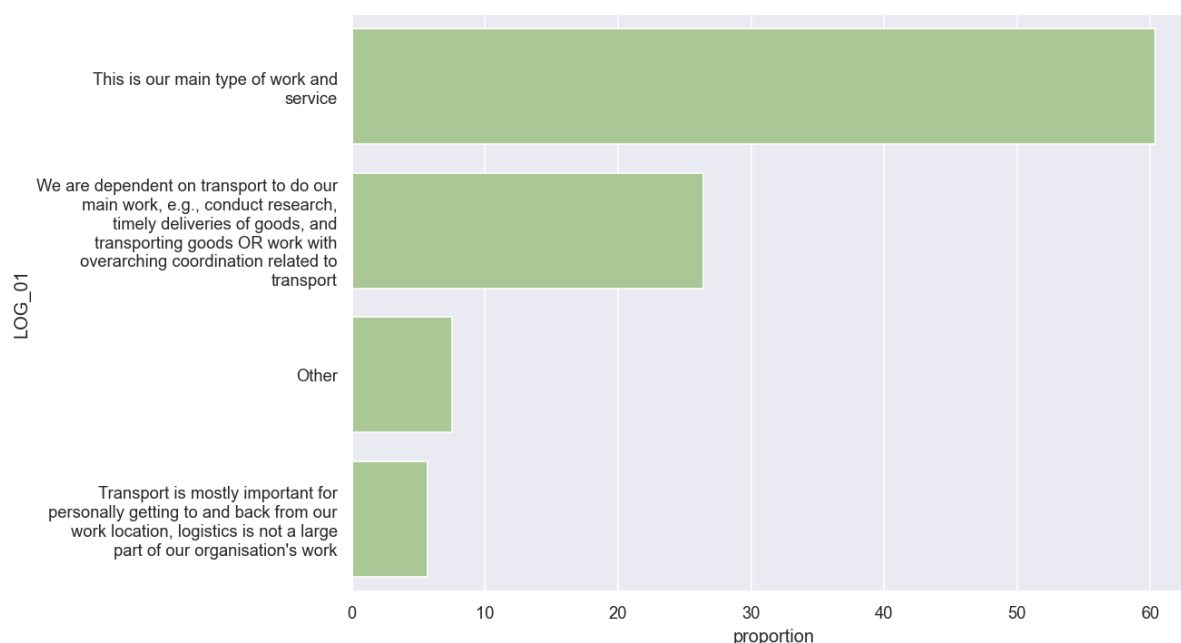


Figure 6: To what degree is transport part of your daily work? LOG\_01. n = 53.

Figure 6 describes to what degree transport is a part of the daily work of the respondent. The purpose of this question was to identify which respondents actively work with transportation. These respondents were presented with a set of transportation-specific questions. The majority of these respondents replied that transportation was a part of their *main type of work and service* (approx. 60 percent). The second largest group were *dependent on transport to do their main work* (i.e. indirectly working with transportation). The smallest proportion of the sample replied that transport is mostly important for personally getting to and back from work. As stated above, those with transportation as the main type of work and service, were asked transportation-specific questions. Figure 7 illustrates which modes of transport were relevant to the organisation of the respondents. The respondents

were presented to the following modes of transportation (in order of highest to lowest share defining them as relevant to the organization): Road, Rail, Maritime, Air and Inland waterways.

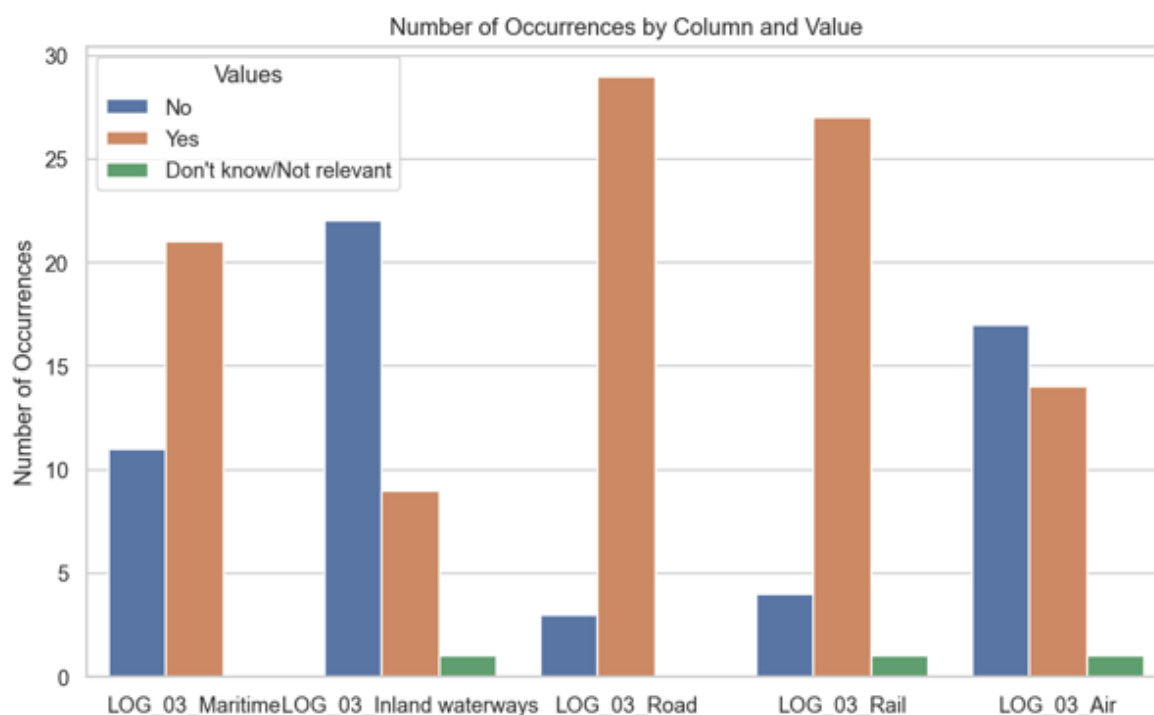


Figure 7: Are any of the following modes of transport relevant to your organisation? LOG\_03. n = 32

## 4.2. First Round Delphi Results

The following section presents the answers on the main questions of this deliverable for the first round of the Delphi.

### 4.2.1. Disruptions

Figure 8 describes the mean value of how much disruption types have affected the respondents' daily work in the last five years. The respondents answered the question using a Likert scale, where 1 is "Not affected" and 5 is "Strongly affected". There are three disruptions with an above middle value effect (mean over the value 3). Ordered from highest to lowest on the mean value, they include the following disruptions: *health emergencies or pandemic*, *regulatory changes (e.g. pandemic restrictions)*, and *war or terrorism*.

The disruptions with the lowest mean values are *wildfire* (lowest), *landslide*, *avalanche and sinkhole* (second lowest) and *earthquake and tsunami* (third lowest). Means approx. around 1.5 indicate that these disruptions have been present but have low effect on daily work in the sample.

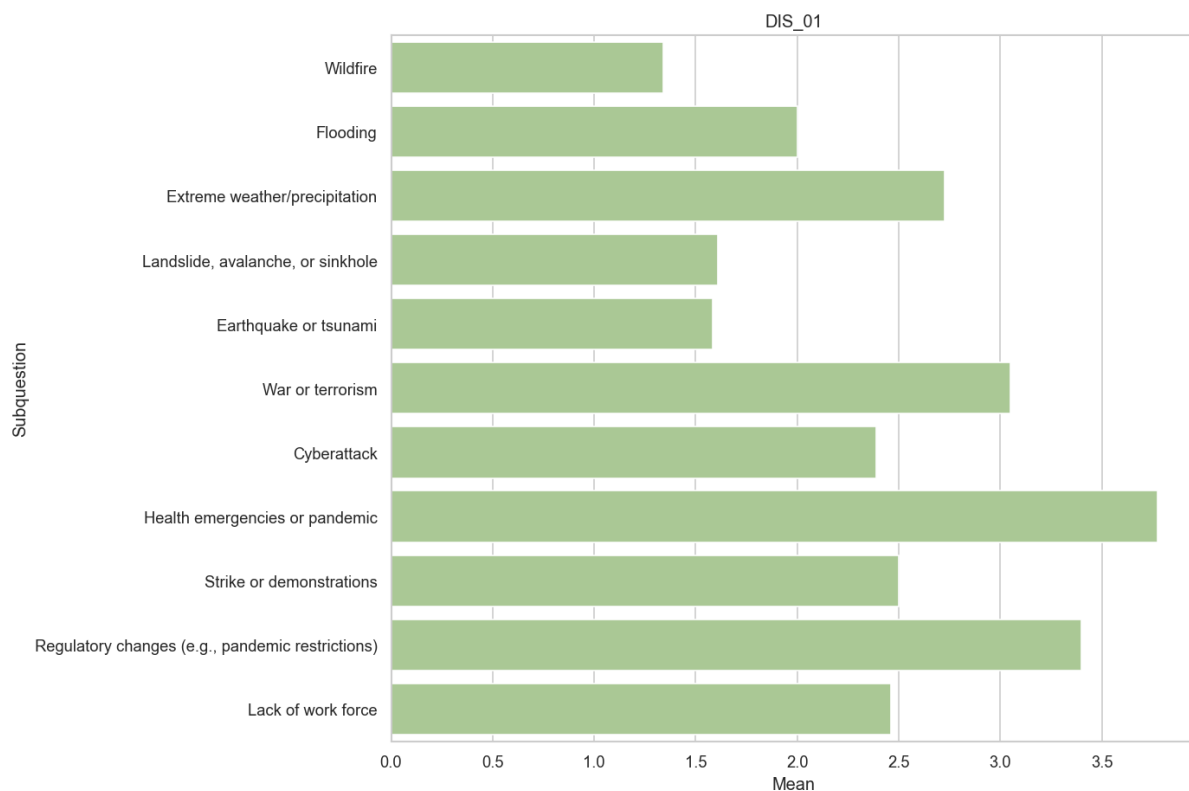


Figure 8: DIS\_01: In your opinion, how much have the following disruptions affected your daily work in the last 5 years? Please answer on a scale from 1-5, where 1 is "Not affected" and 5 is "Strongly affected". If a disruption affecting you is not included, please add it by clicking "ADD INDICATOR". n=40.

Figure 9 describes the consequences of the disruption (type of consequence and severity). The respondents were asked to report the severity of various consequences on a Likert scale. The value 1 means the consequences were "not severe", and 5 means "very severe". Figure 9 reports the means of each consequence. The consequence with the highest mean value was *sudden increase in cost*. The second highest mean was *delayed or increased travel times* and the third highest was *new bottlenecks in transport networks*. The rest of the listed consequences had means below 3, indicating that they were less severe. The consequence with the lowest mean was *pollution and biodegradation*.

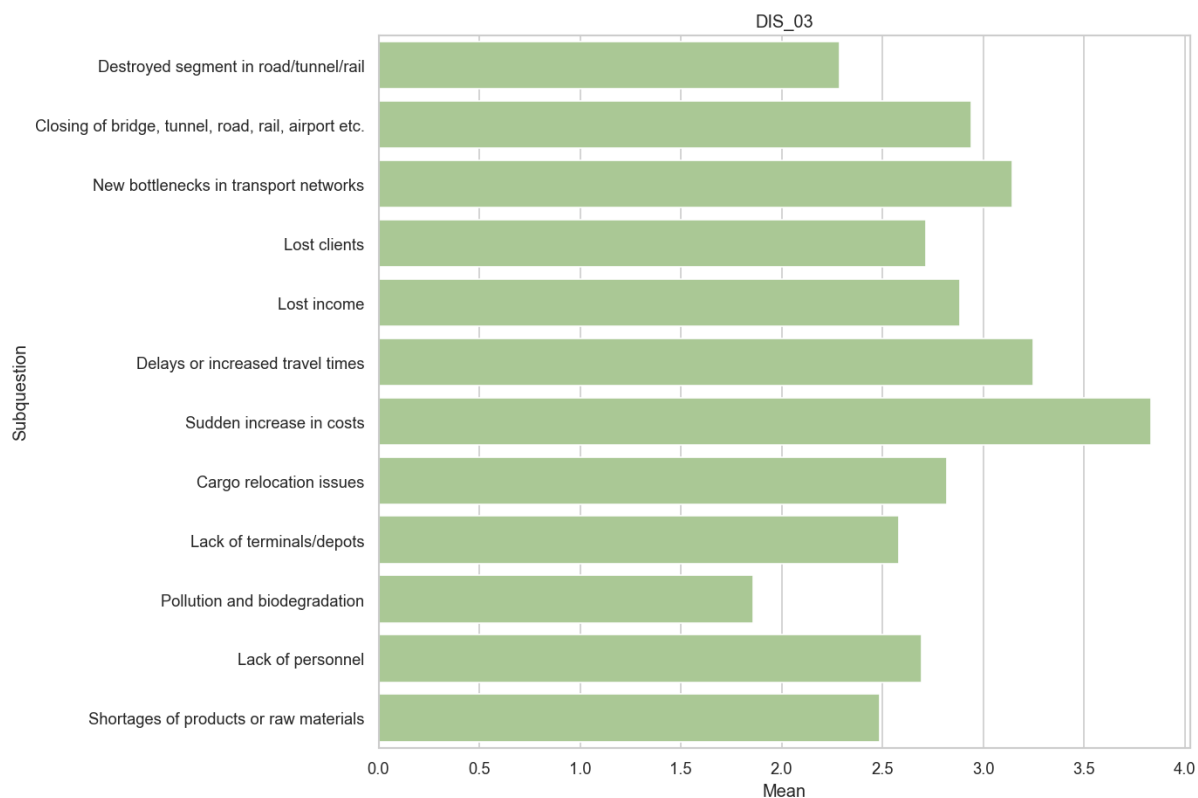


Figure 9: DIS\_03: Think about the type of disruption you were affected most by. Of the following potential consequences, how severe have they been? Please answer on a scale of 1-5 where 1 is "Not severe" and 5 is "Very severe". If an event is not included, please add it by clicking "ADD INDICATOR". N=40

#### 4.2.2. Handling- and Mitigation Strategies

The following section presents the findings on handling- and mitigation strategies of disruptions.

Figure 10 presents the availability of handling strategies or solutions during or right after a disruption. The respondents reported the availability on a scale from 1 (unavailable) to 5 (easily accessible), and the figure reports the mean value for each handling strategy or solution.

The handling strategy or solution with the highest mean value was *dialogue and information internally* (mean higher than 4). The second highest is *adapting our strategies as we go* (mean approx. 3.5). Five handling strategies or solutions had a value above 3 but below 3.5: *Change transportation mode and/or route* and *Collaborate with a new partner* had a mean value just below 3.5. *Change internal processes* and *Continuous improvement or training measures* had between 3 and 3.5 mean value. A step-by-step plan in document/paper had a mean value of just above 3. The least available handling strategy or solution in the sample was *Digital system that automatically shuts down process/mitigates the situation*.

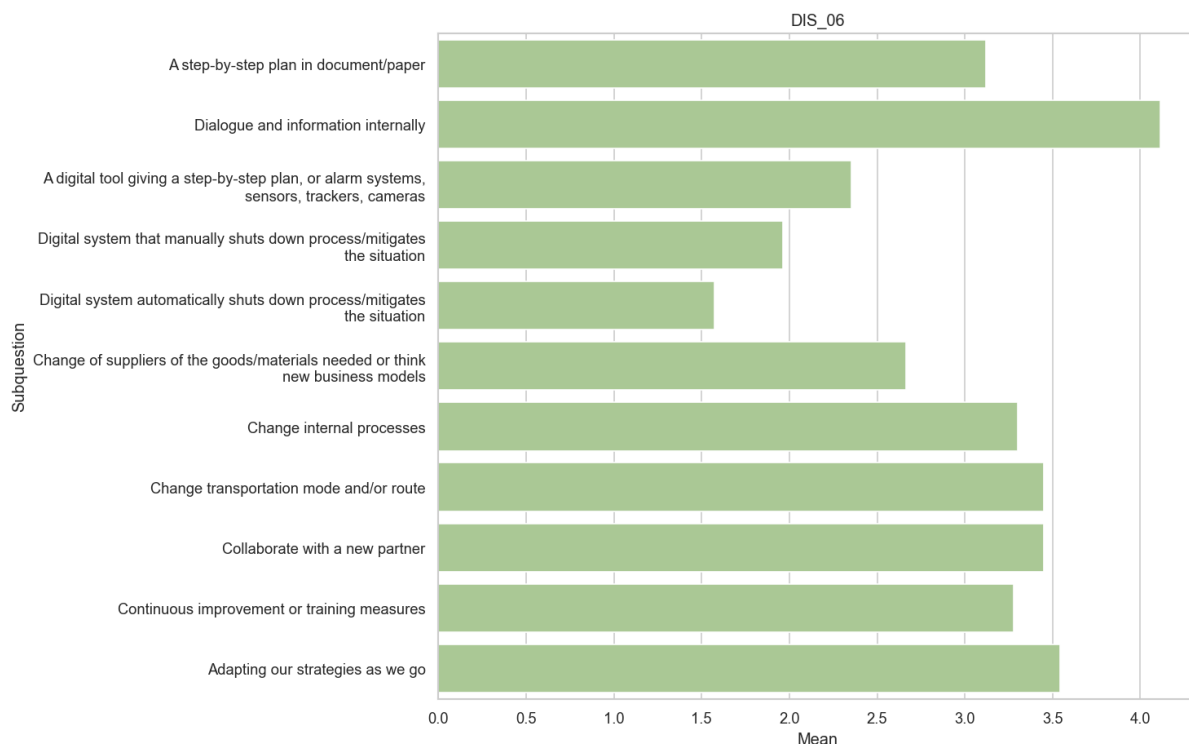


Figure 10: DIS\_06: How available have the following handling strategies or solutions been during or right after a disruption? Answer scale from 1. Unavailable to 5. Easily accessible. Excluding "Don't know" and "not relevant". N=39.

#### 4.2.3. Mitigation Strategies and Resilience

In Task 1.2 (SARIL Project, 2024), a review of the literature has been carried out in order to identify the resilience factors that are important when dealing with disruptive events. Resilience factors here are understood as attributes of an organisation that contribute to minimise the impacts of disruptive events. In Deliverable D1.2, the following resilience factors or indicators have been identified as the most relevant in the literature: preparedness, redundancy, reliability, flexibility, visibility, security, collaboration, recovery and learning.

As can be seen in the previous paragraphs, the available handling strategies with the highest mean value (4.11) is *dialogue and information internally*. Taking into account the resilience factors identified in Task 1.2 (Deliverable D1.2), this handling strategy is closely related to the resilience factors *visibility* and *collaboration*. In the case of *visibility* this refers to the ability to ensure uninterrupted operations by means of real-time access to essential information, enabling stakeholders to make informed decisions and monitor events; while in the case of *collaboration* this refers to the ability to ensure system performance and uninterrupted operations by means of effective cooperation and joint decision-making.

The available handling strategy with the second highest mean value (3.54) is *adapting our strategies as we go*. This handling strategy is closely related to the resilience factor *flexibility* which has been defined in D1.2 as the ability to ensure uninterrupted operations by means of adaptability and reconfiguration of the infrastructure, resources and transportation elements.

The following available handling strategy in importance according to the mean value (3.45) is *change transportation mode and/or route* which is closely related to the resilience factors *redundancy* and

*flexibility*. *Redundancy* has been defined in D1.2 as the ability to ensure uninterrupted operations by means of reserve capacity and the duplication of essential elements.

The following available handling strategy in importance according to the mean value (3.45) is *collaborate with a partner* which is closely related to the resilience factor *collaboration*, previously defined.

It is therefore observed that the resilience factors that are present and related to the handling strategies are *visibility*, *collaboration*, *flexibility* and *redundancy*. Then, analysing the stakeholders' views on the importance of each of the resilience factors (Figure 11 below), the following is observed:

- For organisations whose activity is related to providing and maintaining the physical infrastructure, *redundancy* is the factor with the highest mean value (4.75). However, *visibility*, *collaboration* and *flexibility* are factors with an intermediate mean value (3.75 the three of them). There are other factors such as *reliability* and *recovery* with a higher mean value (4.50).
- For organisations whose activity is related to strategic planning, design, and management of transport logistic networks, *collaboration* and *learning* are the factors with the highest mean value (4.33). However, *visibility* and *flexibility* are factors with an intermediate mean value (3.67 and 3.33 respectively). Finally, *redundancy* is not identified as a relevant factor since it has the lowest mean value of 2.33.
- For organisations whose activity is related to the operational aspects of logistics, focusing on the execution of tasks related to the daily movement of goods, the most important factors to cope with disruptive events are *reliability* (mean value 4.53), *flexibility* (mean value 4.22), *learning* (mean value 4.16), *collaboration* (mean value 4.11) and *recovery* (mean value 4.11).

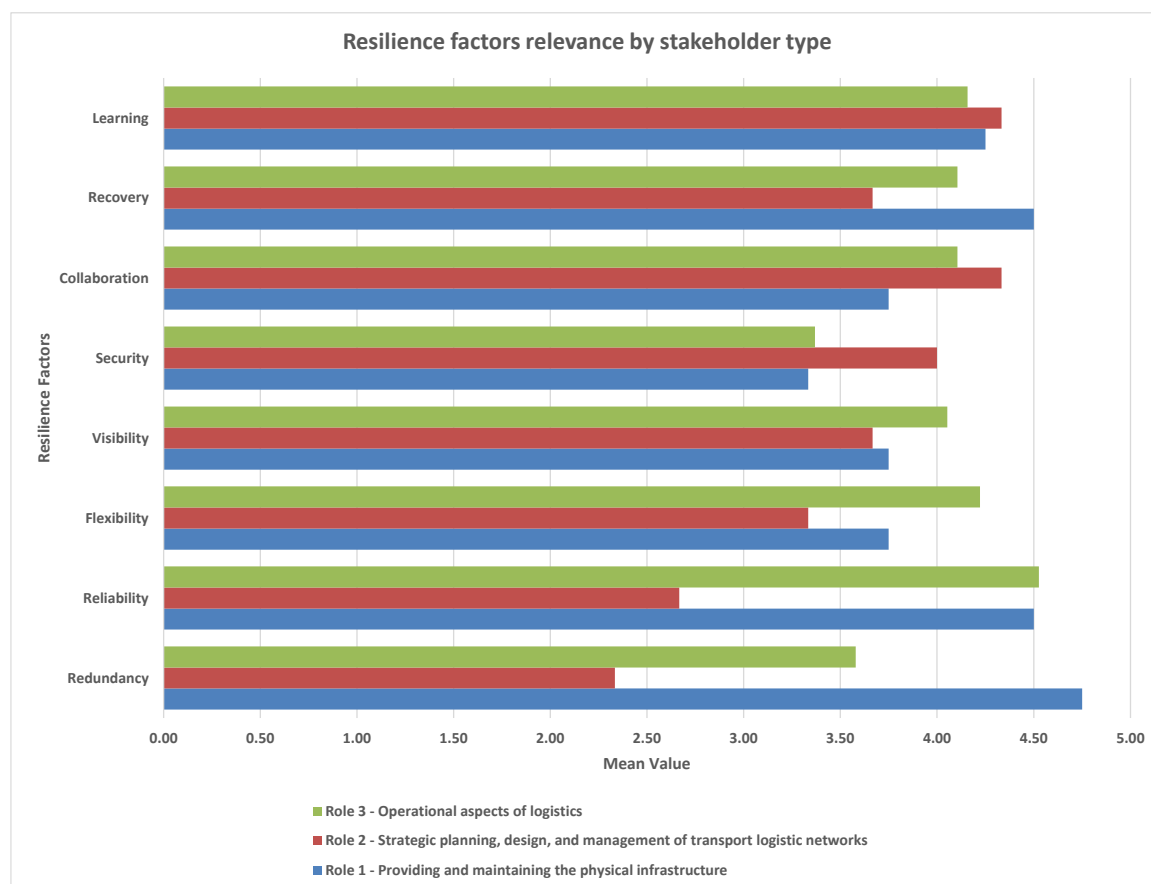


Figure 11: Resilience factors relevance by stakeholder type.

### 4.3. Second Round Delphi and Comparison

In the second round of the survey, 18 respondents from the first round responded.

#### 4.3.1. Disruptions

Figure 12 below shows the responses regarding how much disruptions have affected the stakeholders, from round 2 of the Delphi survey.

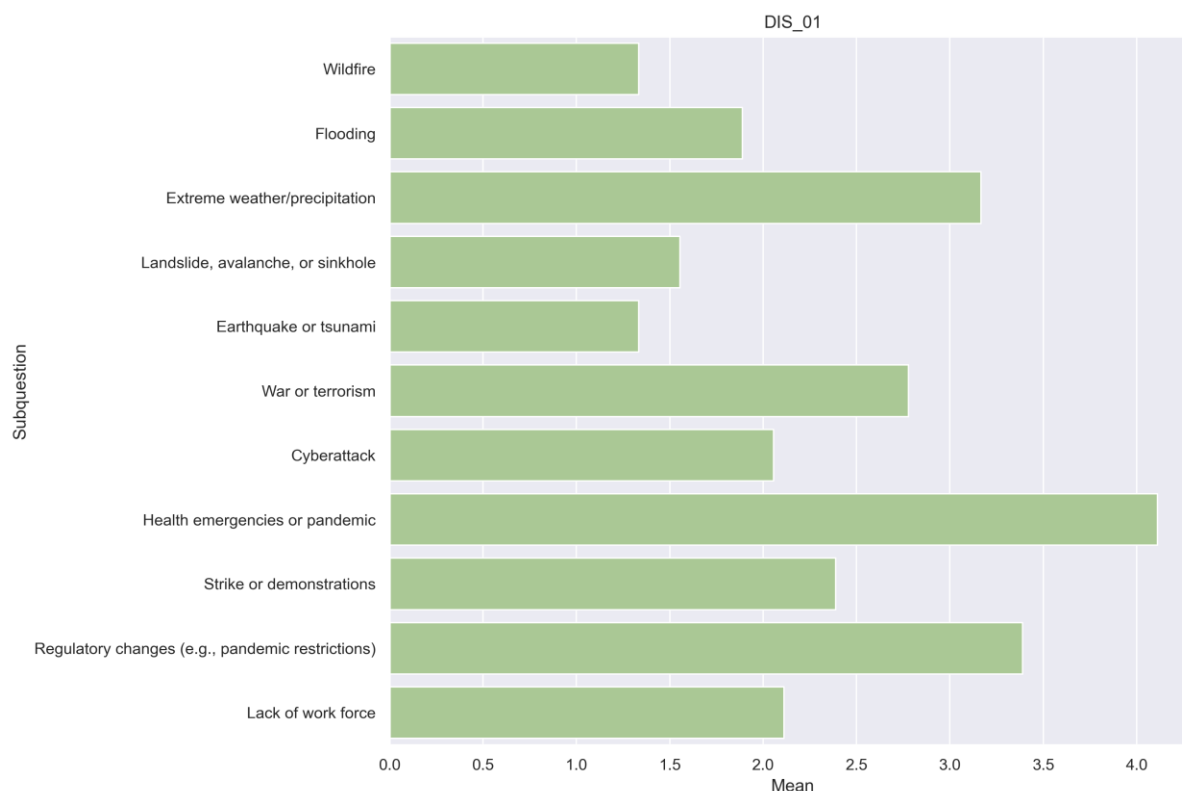


Figure 12: Disruptions Delphi round 2. *In your opinion, how much have the following disruptions affected your daily work in the last 5 years? Please answer on a scale from 1-5, where 1 is "Not affected" and 5 is "Strongly affected". If a disruption affecting you is not included, please add it by clicking "ADD INDICATOR". Excluding "Don't know" and "not relevant". n = 18.*

Considering changes in the Delphi round 2, compared to Delphi round 1 in section 4.2.1. the experience with disruptions and how much organisations has been affected has surprisingly changed somewhat. One can see relatively large changes for *extreme weather*, which has increased from around 2.7 to around 3.2. Further *health emergencies and pandemic* has increased quite some, from around 3.7 to 4.2. *Flooding* has a slight increase as well. *Cyberattack* has however decreased quite a lot, from 2.5 around, to 2. *War or terrorism* has also sunk, from around 3, to 2.7. *Lack of work force* has sunk from almost 2.5, to around 2.1. *Earthquake* has sunk somewhat.

#### 4.3.1. Handling- and Mitigation Strategies

The figure below shows the responses regarding what handling strategies have been available, from round 2 of the Delphi survey.



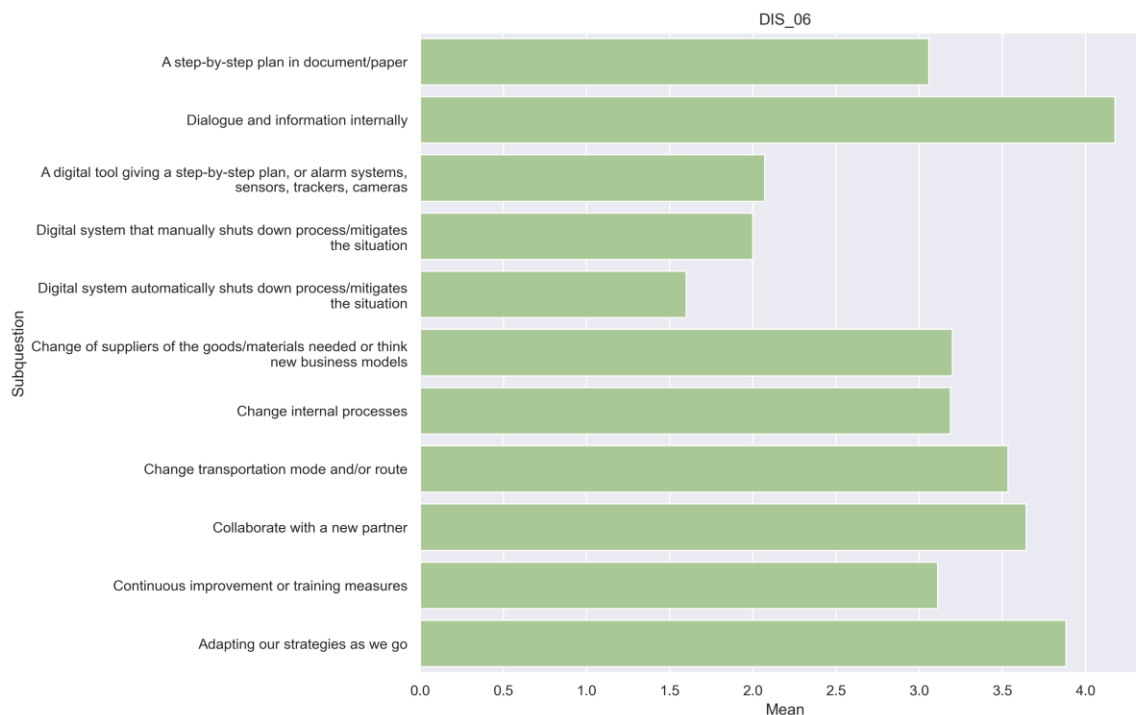


Figure 13: Handling strategies Delphi round 2. How available have the following handling strategies or solutions been during or right after a disruption? Answer scale from 1. Unavailable to 5. Easily accessible. Excluding "Don't know" and "not relevant".  $n = 18$ .

Compared to Delphi round 1, figure 10 in section 4.2.2. access to *dialogue and information internally* is unchanged. However, some clear differences are the changes above 3.5 in mean for some variables. *Adapting our strategies as we go* especially has had the largest change, from around 3.5 and now 3.9. *Collaborate with a new partner* is well above 3.5 and *Change transportation mode/or route* around 3.5, compared to both being just below 3.5 in the first round. The mean for *Digital tool* has sunk almost down to 2 from around 2.3.

#### 4.4. Researchers Sample and Comparison

Apart from the second round of the Delphi, there was created a separate survey addressed to researchers and consultants only. This was in connection with task and deliverable 1.2. but also gave us the chance to get input on the disruptions and handling strategies from this more specific group, without a Delphi set up and using a simpler survey tool.

Figure 14 shows the distribution of the respondents' main area of research or consultancy. Over 35 percent of the respondents reported that they worked within the topics of *sustainability or resilience and adaption to climate change*. Approximately 34 percent responded that their main research or consultancy area were *logistics and multimodal transport*. Approximately 30 percent reported *transport infrastructures* as their main area of research or consultancy. The smallest share (15 percent) reported *other*.

The distribution shows that the survey reached relevant research and consultancy specialist environment(s), because the respondents' main work areas are relevant to the SARIL project.

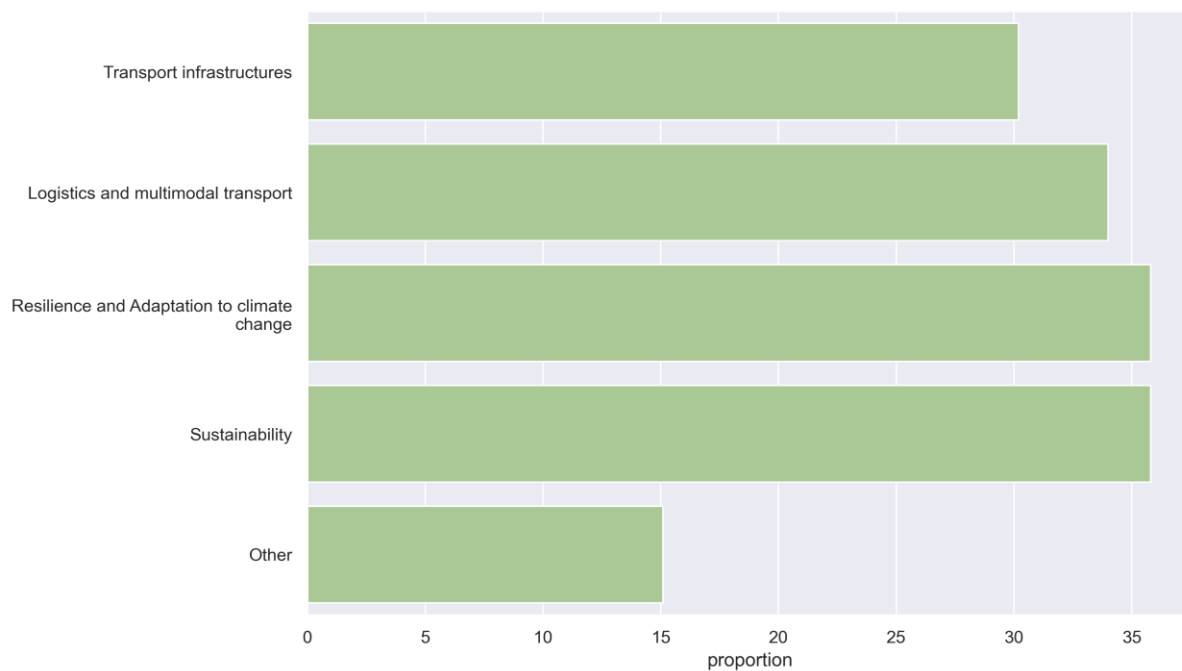


Figure 14: Distribution of the respondents' main area of research or consultancy: What is your main research or consultancy area?  $n = 53$  unique.<sup>2</sup>

#### 4.4.1. Disruptions

Figure 15 describes the mean value of how much disruption types have affected the researchers' and consultants' daily work in the last five years. The respondents answered the question using a Likert scale, where 1 is "Not affected" and 5 is "Strongly affected". The highest mean value is *health emergencies or pandemic*, and the second highest is *regulatory changes*. The other disruptions listed had means below 2.5, indicating that their effect on daily work, on average, were not very substantial amongst respondents in this survey. The disruptions with the lowest mean value (below 1.5) were *landslide, avalanche, or sinkhole, earthquake or tsunami* and *wildfire*.

<sup>2</sup> Some answered more than 1 of the options, total = 80.

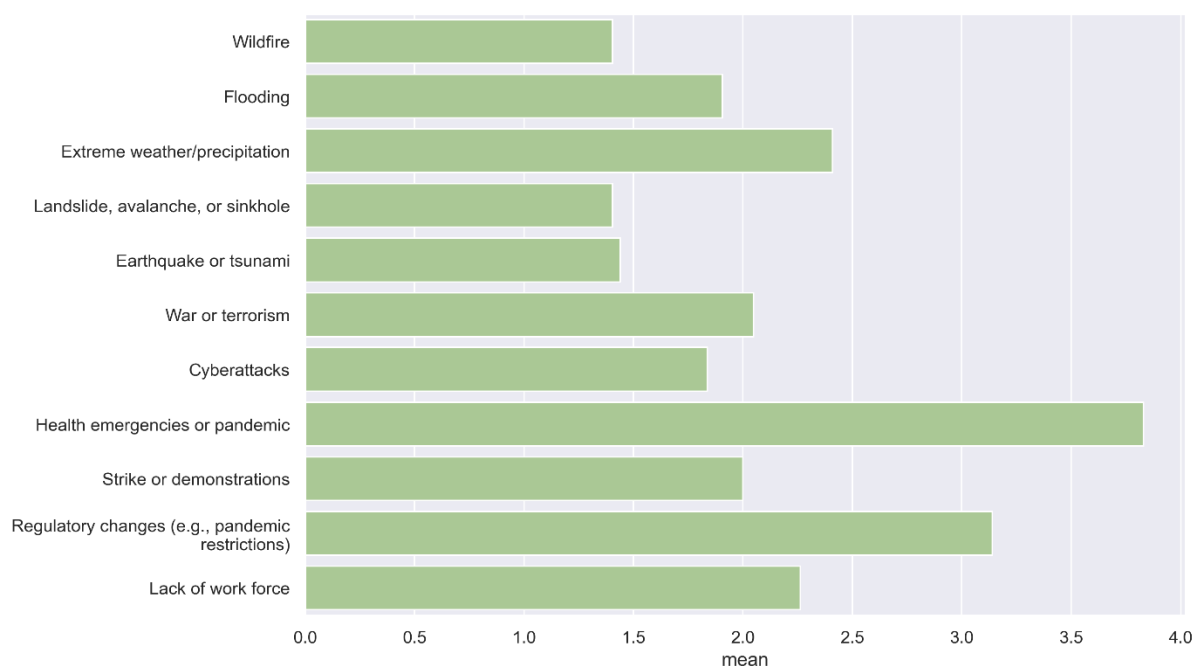


Figure 15: Disruptions, researchers' and consultants' survey. *In your opinion, how much have the following disruptions affected your daily work in the last 5 years? Please answer on a scale from 1-5, where 1 is "Not affected" and 5 is "Strongly affected".* n: 41-43 - varies between subquestions. Excluding "Don't know" and "not relevant".

#### 4.4.2. Handling- and Mitigation Strategies

Figure 16 describes the mean values of how available selected handling strategies or solutions were during or right after a disruption. The respondents were asked to report on a Likert-scale (1-5), where 1 was "Unavailable" and 5 was "Easily accessible".

Four handling strategies or solutions had a mean value over 3 (in order from highest to lowest mean value): *Dialogue and information internally, change transportation mode and/or route, adapting our strategies as we go* and *change internal processes*.

Four handling strategies or solutions had a mean value between 2.5 and 3, meaning they are less accessible than the aforementioned strategies, but can still be considered relevant/important. They were: *Continuous improvement or training measures, collaborate with a new partner, a step-by-step plan in document/paper* and *change of suppliers of the goods/materials needed or think new business models*. The handling strategy with the lowest mean value was *Digital system that automatically shuts down process/mitigates the situation*.

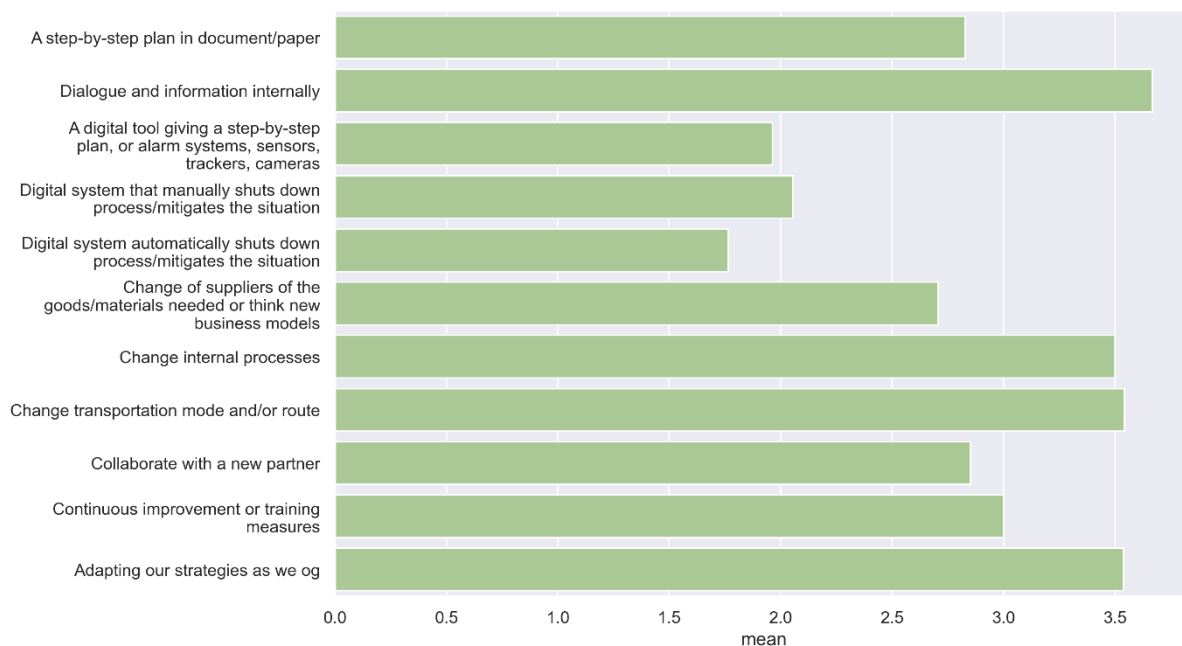


Figure 16: Handling strategies, researchers' and consultants' survey. How available have the following handling strategies or solutions been during or right after a disruption? Answer scale from 1. Unavailable to 5. Easily accessible. Excluding "Don't know" and "not relevant". N= 17-30 - varies between subquestions.

#### 4.4.3. Resilience

The Delphi survey and the AHP outcomes are compared to highlight differences in the importance of resilience factors between stakeholders and researchers. The Delphi survey (see Task 1.3, D1.2, and Section 4.2) reported the importance of resilience factors from the stakeholder's perspective through a rating system using a scale from 1 (unimportant) to 5 (very important). The AHP scoring system resulted from a systematic pairwise comparison carried out by researchers (see D1.2).

While a direct comparison between surveys cannot be accomplished due to differences in how questions were posed, variations and resemblances can be outlined.

Both clusters agreed that reliability is one of the most critical factors in resilience. However, the opposite posture on security is noteworthy, given that stakeholders consider this factor fundamental while researchers define it as the least important. Other factors, such as collaboration and learning, present opposite postures with less intensity. Both clusters consider flexibility and visibility equally important, while no contrast could be extracted for redundancy and recovery.

## 5. Discussion of Results

The following section goes through the main findings and compares, reflect, and discusses where relevant.

The disruption that affected responders most in first round of the Delphi survey is *health emergencies or pandemic* (see Figure 8). The disruption with the second highest impact was *regulatory changes (e.g. pandemic restrictions)*. These results could be explained by the COVID-19 pandemic, and the direct (health) and indirect (regulatory) disruptive effects they have had on daily work. *War or terrorism* could be explained by the war in Ukraine, but also e.g. local terrorism threats. The listed disruptions with the lowest reported impact on daily work was *wildfire*. A potential explanation for this result is that the respondents 1) have less direct experience with wildfire, 2) the handling strategies for wildfire are better developed, making it less disruptive on daily work. Following point one, it could also be due to the population of stakeholders the survey was able to reach.

As the most important consequences of disruptions, and their severity were transportation related is not surprising, since the majority of the sample respondents worked directly with transportation (see Figure 6). Potential explanations of the finding that pollution and biodegradation was considered the least severe consequence of a disruption are: 1) there are more preventive systems regarding this consequence, and/or 2) the consequence is considered less relevant for the respondents in the sample.

The result that the most available handling strategy or solution being dialogue and internal information in both the Delphi survey and survey amongst researchers and consultants, indicates that informal systems are important during and right after a disruption. Furthermore, it indicates that the respondents in both surveys not necessarily have access to formalised systems (or they are not as efficient, as indicated by the lower mean value of a step-by-step plan category), in the handling process, making informal systems more important. It also highlights the importance of communication during the handling of a disruption. That the second most available strategy is *adapting our strategies as we go* indicate that pragmatism is important during or right after a disruption. That the least available handling strategy or solution in the samples of both surveys was *Digital system that automatically shuts down process/mitigates the situation* indicates that access to digital systems during and right after a disruption is limited in the samples studied.

As part of the method, the Delphi survey was sent as a second round to the same sample as described in section 2.3. This was done to discover if there were any consensus or dissensus patterns, or if respondents would change their answers after getting input on the others' responses. Some of the most interesting changes were how the sample changed their responses on how much they were affected by disruptions. *Extreme weather* was one of these, as the mean increased – the sample indicated to be more affected than in the initial survey round. And even *health emergencies and pandemic* increased considerably. When it comes to handling strategies, the mean increased considerably from round 1 to 2, for *adapting our strategies as we go*. The explanation for these changes could be that the sample have been thinking and or discussing with colleagues between round 1 and 2, which has prompted them to change their answers. While the sample from first to second round almost halved, it is interesting still that one could see some noticeable changes in the answers. One could also see some tendency for consensus patterns. For example, some of the answers above the mean of 3 in round one, got even stronger in round two, while some below 3, got even weaker in round two. This could be a sign that that feedback, here seeing the results from round two and what the others answered actually does influence individual responses (Barrios et al., 2021). However, as

the sample that answered the second round was so small, this study did not proceed with calculations to confirm this pattern.

Relating the handling strategies to the resilience factors identified in Deliverable 1.2, it has been observed that the most available strategies: *dialogue and information internally* and *adapting our strategies as we go*; are closely related to the resilience factors *visibility, collaboration, flexibility and redundancy*. These factors, in turn, have been identified as important attributes for minimising the consequences of disruptive events (SARIL Project, 2024). This shows that there is some alignment between the available solutions to handle disruptions and the perception of the attributes needed by an organisation to cope with disruptive events.

In the survey for researchers and consultants, the results show that the main disruptions affecting their daily work were *health emergencies or pandemic*, and *regulatory changes*. These results coincide with Delphi survey results. Furthermore, the researchers and consultants survey results from the question regarding handling strategies indicate that the respondents' strategies and solutions were mainly connected to the COVID-19 pandemic, and less with climate change related disruptions, such as wildfire. These results can be explained by the fact that the researchers and consultants surveyed, are affected to a lower extent by those types of disruptions due to the nature of their work tasks and location they work from. For example, their work could (to a certain extent) be done at more fixed geographical locations, e.g. from home or alternative office spaces. The flexibility/lower dependency on physical presence at a particular work address might explain their low means on impact from weather-related disruptions. Still, they are dependent on communication with coworkers, clients, etc. and may have to change where they work (e.g. route and transportation choices/options). During COVID-19, there was also a lot of "trial and error" since there were no pre-defined guidelines for handling that situation in the beginning. This could explain the highest means on handling strategies regarding adaptation strategies to change place of work, process development and dialogue.

The findings of all the surveys give some important insights that could shape the further work performed in the project. Some disruption types have a more severe impact it seems. Such as pandemic and war related disruptions, compared to for example wildfires. The reason for this could of course be the actual probability and occurrence of these different disruptions but it could also be that disruptions such as pandemic and war, affect larger parts of the value chain and thus supply chain, and thus a larger variety of stakeholders, and that their impact is more long lasting. A wildfire could be resolved faster. This can also be said to be reflected in the question about consequences, where sudden increase in cost is the category with most answers. The longer lasting a disruption is, the higher the cost. The handling strategies to deal with and mitigate the impact of disruptions, is interesting also in the light of the most answered type of disruption. *Dialogue and information internally as well as adapting our strategies as we go*, are non-formal mitigation strategies but they perhaps also reflect a need of flexibility, as e.g., the pandemic showed the surprise and major impact such a disease could have. This is also in line with the findings from the interviews, both how the pandemic was one of the most affecting disruptions (at least for national and EU scenario interviewees) but also the internal communication as a handling strategy. The result that *automated systems*, is one of the handling strategies with lowest availability in this sample, could be both because it perhaps is not flexible enough but also that it is more costly. However, this would need more investigation. Some of the disruptions with a middle-range answer rate are interesting to look closer at: *Cyberattack, strike and demonstrations* and *lack of work force*. While these are not the disruptions with the strongest impact on this sample, they are disruptions that could have a comprehensive or wide impact such as the pandemic did and have major repercussions in the supply chains, and the wider logistics and transport networks.

### 5.1. Limitations and Lessons Learned

The following considerations regarding limitations and lessons learned of this deliverable is related to 1) the method, 2) the recruitment, 3) the collaboration to create the survey and 4) the tool used for sending the survey. Weaknesses in all these points could jointly have contributed to the low number of respondents and high number of drop-outs.

First and foremost, the Delphi-method itself necessitated the need to ask the respondents to login. This was the only way to make sure it was possible to do a proper round 2, with the chance to edit one's answer. However, this could have represented a barrier for the user. On the other hand, creating a user and a password was a quick process, that did not need the respondents to check the email or anything similar, making it easy in itself.

Another aspect was the approach for reaching the stakeholders, i.e. related to the recruitment itself. With the help of the whole consortium, and especially those working with this task, there was created a list for reaching stakeholders, comprising 127 potential respondents to whom there was sent an invitation to respond to the survey. Using more time on creating this list, could potentially have gotten more respondents to answer the survey.

Regarding the tool used for collecting the responses, the choice landed on the one abiding with GDPR and at the same time offering a Delphi-set up. But an issue that turned up with the tool during the process, was the translations into several languages to reach a wider group. With the tool applied, this was a major challenge because it was time consuming, also regarding the localisation of errors in the coding. There were also several bugs in the system that took time to pinpoint.

Thirdly, after the first round of making the survey questions ready, a collaboration with the sister project ReMuNet started. This was fruitful for reaching out to a larger population of potential respondents. However, it made the survey much longer than intended, as both projects had survey questions that were crucial to add. This could have been one major reason for the drop outs along the way, thus affecting the end response for both projects. However, if the two projects had sent out each their own survey, this could have led to a high stakeholder fatigue. Also, the timing of when the survey was sent out, made the survey launch somewhat too close to Christmas, which also might have been an influencing factor on the low response rate.

As mentioned, all of these issues, could have contributed to the low response rate. Here, one can draw the conclusion that surveys in future projects need to follow a simpler methodology and that the used tool needs to be adjusted in collaboration with the tool provider or replaced by a more accessible one. One could also consider using a panel – meaning paying a survey supplier in helping us getting a good sample size. This is however a very large expense.

Regarding the content of the study and the questions asked, the study could have benefitted from questions directly related to governance. As the interviews in regional scenario found, there is a need for more collaboration between transport companies and authorities for preparing for disruptions. As such regulatory and policy issues regarding this would have been interesting to cover. While time and resources limited such an endeavour in the survey, the project aims to focus on governance as one of the sub-topics in Task 1.4. of the project (Co-creation of challenges, requirements, and future expectations through participatory foresight of stakeholders) where we will have workshops with relevant stakeholders.



## 6. Main Conclusions

The Delphi survey (both rounds) and the researchers' survey found *health emergencies or pandemic* to be the most prevalent disruption affecting the samples. This was closely followed by *regulatory changes*, which was not unexpected. *War and terrorism* came third. These are all what one could term *comprehensive* disruptions, as they can have a wider impact on the whole value chain, not just on a specific point in the transport infrastructure. While disruptions such as wildfires and cyberattacks also were experienced by respondents, the COVID-19 pandemic seems to have had most severe consequences for the respondents. This is also confirmed and explained in the interview findings. E.g., the pandemic led to oversupply of cargo in terminals and ports and not enough vehicles to move the cargo. And in general fluctuations of cargo volume was a negative impact of the pandemic, but also of the war between Russia and Ukraine.

Considering this, one should be weary of changes in magnitude on disruptions such as cyberattacks, strikes and demonstrations and lack of work force, as they could negatively impact the whole transport system. This is exemplified in the national scenario, as the interviews refers to the major impact striking hauliers can have on the whole transport system.

One of the most answered disruptions, and which also showed an increase in impact for the sample from round 1 to 2 of the Delphi survey, was *extreme weather*. This, as well as wildfires, are types of disruptions one could expect more of in the future as the climate crisis progresses.

The main finding regarding handling strategies is how informal systems are important during and right after a disruption, through the high response on e.g., *internal dialogue and information* as an important handling strategy in the online surveys. This could of course be caused by not having a more formal or automated systems, as the survey also shows, or that the system they have is not effective enough. But as *adapting our strategies as we go* was the second most responded strategy, this shows the importance of having flexibility. The COVID-19 pandemic showed just how surprising and devastating disruptions can be on organisations and large parts of society. The resilience factors identified in the surveys, confirms this link between handling strategies and attributes needed in organisations to deal with disruptions, e.g., flexibility and collaboration. *Collaboration with new partner* and *change of transportation mode and/or route* were also prevalent handling strategies in this regard and to keep in mind for building resilience. *Collaboration with a new partner* was also a strategy increased from round 1 to 2.

One of the main limitations is the low response rate. In section 2.6. we point to several factors that could have caused this, such as survey length and recruitment approach. Another important point is related to the Delphi survey method and the tool applied. While a full Delphi survey can be an interesting approach for investigating stakeholders' changing perspectives, one must also weigh the expected benefit against the time, complexity and costs of doing it.

Some of the implications of the findings from this deliverable are to be weary of the handling strategies organisations actually use, such as internal dialogue and the adaptability of strategies as these could help organisations' resilience. However, one must also keep in mind the lack of access to digitalised and automated systems. The interviews pointed among others to the need of greater data sharing, cross-sector collaboration and digital tools for dealing with disruptions and improving data flow. Digital tools could play a major role in mitigating disruptions in the future as they could make strategies more efficient, potentially safer and helping in a more seamless collaboration with other organisations, and thus improve resilience.



## 7. Acknowledgements

We want to thank everyone contributing to making this Deliverable and not least the surveys a possibility. Thank you to all partners helping out with reaching out to potential responders, to internal SARIL reviewers. Finally, we wish to thank especially those who took of their valuable time in answering the survey(s). Table 6 below shows organisations and companies that responded to the survey(s) and agreed to have their organisation name shared. The list is not exhaustive of the full sample but shows the variety of the different types of stakeholders and organisations that were contributing to the knowledge building of this work. These are listed according to country for main office.

Company or organisation responding to survey	Country of main office
Hafen Wien	Austria
Adriafer Rail Services S.r.l.	Italy
TCGL (Grupo ETE)	Portugal
St. Olavs hospital, Logistics dept.	Norway
FIEGE Gruppe	Germany
Danish Red Cross	Denmark
Codognotto Italia S.p.A.	Italy
Grupo Gof	Spain
Rangel Invest SA	Portugal
Universidad de Zaragoza	Spain
RFI (Rete Ferroviaria Italiana)	Italy
CITYLOGIN IBERICA S.L.	Spain
Contargo GmbH & Co. KG	Germany
Istituto sui Trasporti e la Logistica - ITL	Italy
NSBS, the Bulgarian National Freight Forwarding Association	Bulgary
The Association of Road Transport Operators ČESMAD BOHEMIA	Check Republic
Jernbanedirektoratet (The Norwegian Rail Directorate)	Norway
Hafen Wien	Austria
Adriafer Rail Services S.r.l.	Italy

Table 6: Some of the organizations and companies who responded to the survey(s) and gave authorization to be acknowledged.

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