Ploto

D2.1

Definition of the Requirements, Use Cases and System Specifications 1st version

Project name

Deployment and Assessment of Predictive modelling, environmentally sustainable and emerging digital technologies and tools for improving the resilience of IWW against Climate change and other extremes

HORIZON INNOVATION ACTIONS | PROJECT NO. 101069941

Call HORIZON-CL5-2021-D6-01

Co-funded by
the European Union

Ploto

Dissemination level	Public (PU) - fully open
Type of deliverable	R - Document, report
Work package	WP2 – End-User Requirements and Platform Design
Deliverable number	D2.1 Definition of the Requirements, Use Cases and System Specifications 1st version
Status - version, date	Final – V1.0, 28/02/2023
Deliverable leader	RISA
Contractual date of delivery	28/02/2023
Keywords	Inland Waterways, user needs, requirements, resilience

Quality Control

	Name	Organisation	Date
Peer review 1	Ahmed Jaber Bálint Csonka	BME	22/02/2023
Peer review 2	Philipp Selzer Vincent Schmitz	ULIEGE	23/02/2023

Version History

Version	Date	Author	Summary of changes
0.1	20/10/2022	RISA	Table of Contents, First draft of document
0.2	10/11/2022	BME	Provided input to several Chapters (methodology, user needs description)
0.3	21/11/2022	All technical partners	Proved input to PLOTO moduls description and feedback to end user requirements
0.4	05/12/2022	All end-users	Proved input to end user requirements, use cases description
0.5	15/12/2022	RISA	Provided input to several Chapters (methodology, user requirements, modules, use cases)

0.6	10/01/2023	RISA, BME	Provided input to several Chapters (methodology, user needs, user requirements, modules, use cases)
0.7	14/02/2023	RISA	Complete draft version for internal review
0.8	22/02/2023	BME	Internal review updates
0.9	23/02/2023	ULIEGE	Internal review updates
1.0	28/02/2023	RISA	Final submitted version

Legal Disclaimer

List of figures

List of tables

List of abbreviations and acronyms

Abbreviation	Meaning
AIS	Automatic Identification System
CA	Consortium Agreement
COP	Common Operational Picture
DSS	Decision Support System
Dx.x	Deliverable x.x
EC	European Commission
ELOHA	Ecological Limits of Hydrologic Alteration
EU	European Union
FR	Functional Requirements
GA	Grant Agreement
IMS	Incident Management System
IS	Information System
IR	Interface Requirements
ISO	International Standardisation Organisation
IWAT	IWW Assessment Tool
IWW	Inland WaterWays
MT	Ministry of Transport
Mx	Month x
NFR	Non-Functional Requirements
PR	Process Requirements
RIS	River Information System
Tx.x	Task x.x
UID	Unique Identification
UR	Usability Requirements
WP	Work Package

Executive Summary

PLOTO project aims at increasing the resilience of the Inland WaterWays (IWW) infrastructures and the connected hinterland- infrastructures, thus ensuring reliable network availability under unfavourable conditions, such as extreme weather, accidents and other kind of hazards. PLOTO's main target is to combine downscaled climate change scenarios (applied to IWW infrastructures) with simulation tools and actual data, so as to provide the relevant authorities and their operators with an integrated tool able to support more effective management of their infrastructures at strategic and operational levels. The PLOTO integrated platform and its tools will be validated in three case studies in Belgium, Romania, and Hungary.

The aim of this report is to: (a) present a literature review on issues related to technical, regulatory and financial aspects that shall be considered for the development of the PLOTO integrated system (T2.1); (b) identify the end- user needs (T2.1); (c) produce a detailed specification of PLOTO end-user requirements (T2.2); (d) describe the PLOTO platform's modules and; (e) provide initial information of the use cases that will be used for their definition (in deliverable D2.2 "Definition of the Requirements, Use Cases and System Specifications final version").

1 Introduction

1.1 Project information

The project entitled **"Deployment and Assessment of Predictive modelling, environmentally sustainable and emerging digital technologies and tools for improving the resilience of IWW against Climate change and other extremes (PLOTO)"** aims at increasing the resilience of the Inland WaterWays (IWW) infrastructures and the connected land- infrastructures, thus ensuring reliable network availability under unfavourable conditions, such as extreme weather, accidents and other kind of hazards. The main target is to combine downscaled climate change scenarios (applied to IWW infrastructures) with simulation tools and actual data, so as to provide the relevant authorities and their operators with an integrated tool able to support more effective management of their infrastructures at strategic and operational levels. Towards this direction, PLOTO aims to:

- Use high-resolution modelling data for the determination and assessment of the climatic risk of the selected transport infrastructures and associated expected damages.
- Use existing data from various sources with new types of sensor-generated data (computer vision) to feed the used simulator.
- Utilise tailored weather forecasts (combining seamlessly all available data sources) for specific hot spots, providing early warnings with corresponding impact assessment in real-time.
- Develop improved multi-temporal, multi-sensor UAV- and satellite-based observations with robust spectral analysis, computer vision and machine learning-based assessment for diverse transport infrastructures.
- Design and implement an integrated Resilience Assessment Platform environment as an innovative planning tool that will permit a quantitative resilience assessment through an end-to-end simulation environment, running "what-if" impact/risk/resilience assessment scenarios. The effects of adaptation measures can be investigated by changing the hazard, exposure and vulnerability input parameters.
- Design and implement a Common Operational Picture (COP), including an enhanced visualisation interface and an Incident Management System (IMS).

The PLOTO integrated platform and its tools will be validated in three case studies in Belgium, Romania and Hungary.

1.2 Purpose of the deliverable

Deliverable 2.1 "Definition of the requirements, use cases and system specifications 1st version" is one of the three (3) Deliverables of WP2 and is related to Tasks T2.1 "End-user needs and good practices analysis of adaptation and mitigation measures" and T2.2 "Specification of system requirements, Use Cases, Scenarios Definition and KPIs". This first version of D2.1 (M6) aims to: (a) present a literature review on issues related to technical, regulatory and financial aspects that shall be considered for the development of the PLOTO integrated system (T2.1); (b) identify the end-user needs (T2.1); (c) produce a detailed specification of PLOTO end-user requirements (T2.2); (d) describe the PLOTO platform's modules and; (e) provide initial information on the use cases and scenarios that will be used to validate the PLOTO platform in WP7.

Attainment of the objectives and explanation of deviations

This Deliverable is related to PLOTO Objective 2 "First version of setting up the Use Cases and System Requirements through the End-Users Workshops". The specific objective has been achieved in full and as scheduled.

1.3 Intended audience

As the dissemination level of this Deliverable is public, it will be openly available to all stakeholders, such as public authorities, IWW and other hinterland infrastructure owners and operators, researchers and technology providers, as well as decision and policy makers interested in a report presenting Inland Waterways end-user needs and requirements towards the design and development of a system that improves the resilience of IWW against Climate change and other extremes. This Deliverable is specifically intended for all PLOTO partners as it analyses end-user needs and requirements, as well as the system modules and use cases/scenarios.

1.4 Structure of the deliverable and its relation with other work packages/deliverables

The Deliverable has been structured as follows:

Section 1. Describes PLOTO's aim as well as this document's purpose, intended audience and structure.

Section 2. Describes the methodology followed in this Deliverable.

Section 3. Presents the normative literature on IWW, PLOTO end-user needs and good practices analysis of adaptation and mitigation measures.

Section 4. Presents PLOTO end-user requirements.

Section 5. Presents PLOTO system modules.

Section 6. Presents initial information on the use cases and scenarios.

Section 7. Concludes the Deliverable by summarising the main outcomes and referring to future work.

2 Methodology

This deliverable is linked to Tasks T2.1 "End-user needs and good practices analysis of adaptation and mitigation measures (M1-M4; BME)" and T2.2 "Specification of system requirements, Use Cases, Scenarios Definition and KPIs" (M3-M10; RISA)".

The Deliverable aims to present several aspects related to the aforementioned Tasks, and more specifically to: (a) analyse the normative literature of issues related to technical, regulatory and financial aspects that shall be considered for the development of the PLOTO integrated system (T2.1 aim); (b) identify the end-user needs (T2.1 aim); (c) define end-user requirements; (d) describe PLOTO platform's modules (T2.2 aim); (e) as well as describe information related to use cases and scenarios that will be used to validate the PLOTO platform in WP7 (T2.2 aim).

To meet the objectives of the Deliverable, PLOTO Task Leaders and contributing partners cooperated and applied several techniques and methods in a specific timeframe (Figure 1).

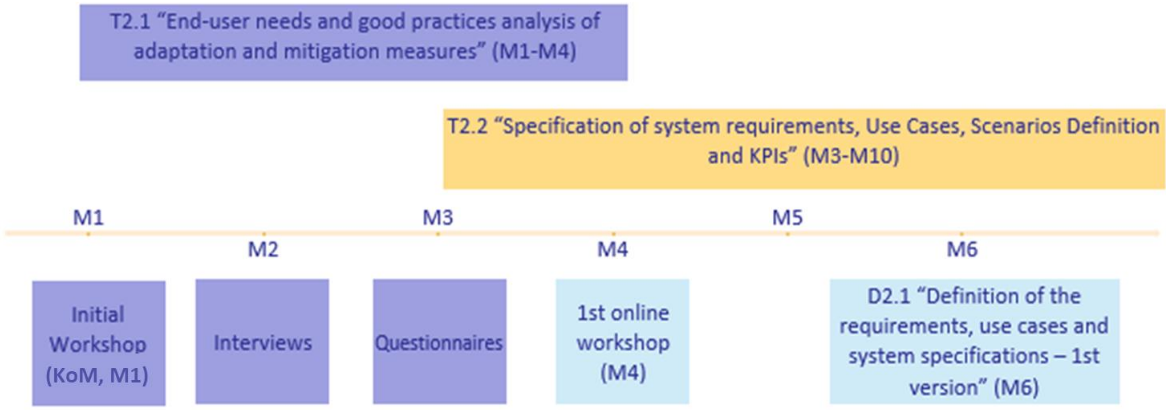

Figure 1: Time plan and milestones

In the following paragraphs, the specific methodology that was used to meet each Task's aims, time plan, and milestones (as defined above), will be described.

2.1 T2.1 "End-user needs and good practices analysis of adaptation and mitigation measures" methodology

In order to determine the data collection and analysis method, we performed **preliminary interviews** and discussions with several stakeholders as well as organized a **workshop at the kick-off meeting.** The framework of questionnaire survey and deep interviews was created based on the answers. The structure and content of deep interviews and questionnaire surveys are largely coincided.

2.1.1. Literature review

The first step in working on a given topic is to understand its current situation. One element of this is a review of the literature on the topic. Accordingly, the literature review aims to identify the current situation, to learn about the solutions that have been planned and implemented so far, and to identify the gaps that will help to identify the areas for improvement and the related elements.

The search for relevant literature was based on the following keywords:

- Climate change
- Digital information services
- Droughts
- Ecosystem services
- Flooding
- Inland waterways
- Inland water protection
- Impacts on transport
- Low water levels
- River discharges
- Sustainable transportation
- Water level fluctuations
- Weather effects

Search was done for regulations and for professional and scientific literature. Legislation and regulations have been discussed in a top-down approach, which means that EU legislation relevant to the topic has been dealt with first, followed by legislation and regulations in the countries where the demonstrations will take place.

The sources of scientific literature include scientific books, journal articles, conference articles, other documents etc.. The main search platform was Google Scholar, but also the main scientific portals such as IEEE Xplore, ScienceDirect and ResearchGate were used.

The reviewed literature was divided into four main groups:

1. Regulation (EU, Romania, Belgium, Hungary).
2. Weather impacts and resilience (including climate change, sustainability, professional and scientific literature).
3. Logistics (impacts on freight transport, economic issues, professional and scientific literature).
4. Information systems (existent systems, technology for improvement, professional and scientific literature).

Summarising the literature available in each of these groups and sections, a number of key findings have been drawn.

2.1.2. Deep interviews

The purpose of the deep interviews was to reveal the end-user (representatives of relevant stakeholders) needs from their perspective and to establish a comprehensive description about their requests and suggestions regarding information service development.

Our consortium partners appointed 21 people representing the stakeholders from various fields of activity. We contacted all of them and 10 persons replied and accepted our invitation for the interviews. They were as follows (Table 1):

Table 1: Representatives of stakeholders involved in deep interviews

Name	Title	Country	Organization	Date and time in year 2022
BARNETT, Chris	Project Developer	United Kingdom	Canal & River Trust (Operator of waterways)	30 November 14:00
COOLS, Mario	Professor (transport research)	Belgium	ULiége (Research Institute)	2 December 9:00
FÁBIÁN, Zoltán	Managing Director	Hungary	MAHART Container Center Ltd.	28 November 13:00
HOLICZA, András	Managing Director	Hungary	Dunatár Ltd. (Logistics Operator)	18 November 10:00
KOZSDI, Béla	Maging Director	Hungary	Human Shipping Ltd.	7 December 12:30
MESTER, László	Managing Director	Hungary	Ferroport Ltd.	13 December 9:00
SCRIECIU, Albert	Researcher	Romania	The National Research-Development Institute for Marine Geology and Geoecology - GeoEcoMar	12 December 14:00
SEMAN, Ana Maria	Coordinator	Romania	WWF Central and Eastern Europe	14 December 10:00
SZALMA, Béla	President	Hungary	Hungarian Port Association	1 December 15:00
van der WEEN, Rudy	Advisor	Europe	Inland Waterways International (NGO)	16 December 10:00

They shared their everyday experiences, opinions, expectations during the free and unstrained discussions. The duration of each interview varied between 30 and 60 minutes. Most of the discussions were recorded and then interview transcripts were created by summarization of main thoughts and statements. We summarized the most relevant statements and key findings (Section 3.3).

2.1.3. Questionnaire survey

Structure

The questionnaire survey aimed to reveal the major impacts of weather and climate change on inland waterways (IWW) among a wider audience, the users of IWW (transport and logistics operators, infrastructure operators, and other stakeholders). The structure of the questionnaire was based on the result of preliminary interviews and literature review. The sections of the questionnaire are the following:

I. General information (activity type, service area).
II. Effects of weather (significance, duration).
III. Consequences of weather effects on shipment, loading, storage.
IV. Available information services (communication channels, accuracy).
V. Needed information services (importance, forecast in advance).

The questionnaire was developed by system and process-oriented approach taking into consideration structure and content of other surveys. Each respondent grasps the content of questions in a different manner (Hosseininasab, 2015); therefore, a clear formulation of questions is important to reduce the distance between the provided answers. The goal was to minimise the number of biased answers that may indirectly influence the survey outcome (Roy, Tavana, Banerjee, & Di Caprio, 2016).
All in all, 21 questions were formulated. In some cases, a question contains several sub-questions according to weather effects and impact areas. Closed and open questions were applied. The considered closed-question types were:

- single choice (in some cases with a numerical rating or a 1-5 Likert-scale (Nemoto & Beglar, 2014).
- multiple choice,
- ranking.

Only the relevant questions had to be answered. If a question was irrelevant for the respondent, the specific section could have been skipped to speed up the filling-out time.

The considered weather effects based on the result of preliminary interviews, literature reviews and the frequency of an effect in Europe are:

- low water level,
- high water level (flood),
- fog,
- icing (extreme cold),
- intense precipitation,
- strong wind (storm),
- heatwave.

The weather effects and climate change have impacts on different IWW-related activity types. Three main *k* impact areas were considered in the questionnaire:

- shipment,
- loading,
- storage.

The questionnaire was initially tested a focus group. The members were selected from the students and experienced colleagues of the Budapest University of Technology and Economics and the Hungarian PLOTO partners. Moreover, the questionnaire was shared among the PLOTO partners for review. Considering the comments (e.g., adding new questions related to the safety plan and planning strategy), the questionnaire was modified. The questionnaire survey can be found in Annex 2.

The EUSurvey open-source platform supported by the European Commission ISA programme was used, which promotes interoperability solutions for the European public. (https://ec.europa.eu/eusurvey/). The questionnaire was available in 5 languages (English, German, French, Hungarian, Romanian).

The respondents were selected using a snowball method when members of a certain group with similar attributes answered. Several channels were used to spread the survey:

- Shared in social media: PLOTO LinkedIn (with 62 followers), PLATINA LinkedIn (with 332 followers).
- The link was sent to IWW professionals (e.g., Ismael Torres, Manfred Seitz, Nico De Cauwer, Hans Rook, Nik Delmeire, Maria Mota, Ludmila Filina-Dawidowicz).
- The link was shared via the EUSurvey portal (to members of EMSA, CINEA.C, CINEA.B (app. 500 members).
- Shared with the member of similar projects (GreenWin, FOR FREIGHT).
- PLOTO partners shared the link via their inner communication channels (e.g., 106 partners of BSZL Freeport of Budapest).

Analysis method

According to the different question types, the analysis is different:

- In the case of single and multiple-choice questions, the number of answers to an option was summarised and aggregated within the division of the total number of respondents, or according to the number of respondents who chose an option. Namely, the percentage of an option selected is calculated.
- If values are assigned to the options (such as in the case of duration calculation), the values according to each response are averaged.
- In the case of Likert-scale questions, the values according to each response are averaged. The result is one value.

The weighted significance of weather effects was calculated considering several questions. This value expresses how a weather condition influences the IWW sector (contribution to causing consequences). Steps are as follows:

1. Converting average relevancy to a p_k percentage scale (1), where r_k is the average relevance of impact area k.

$$p_k = \frac{r_k}{\sum r_k} \cdot 100 \; [\%] \qquad (1)$$

2. Converting the number of respondents who answered there is a connection between weather condition i and consequence j in impact area k (n_(i,j,k)) into a percentage scale for each

impact area; expressing the frequency of weather condition in causes consequences in impact area k (2).

$$q_{i,k} = \frac{n_{i,j,k}}{\sum n_{i,j,k}} \cdot 100\ [\%] \quad (2)$$

3. Calculating the weighted significance of weather condition *i* (3).

$$w_i = \sum_k p_k \cdot q_{i,k} \quad (3)$$

2.2 T2.2 "Specification of system requirements, Use Cases, Scenarios Definition and KPIs" methodology

Task 2.2 "Specification of system requirements, Use Cases, Scenarios Definition and KPIs" aims to:

- Identify end-user requirements (based on end-user needs, as presented by T2.1).
- Identify system requirements (matched with end-user requirements).
- Define PLOTO modules.
- Describe use cases and scenarios.
- Define Key Performance Areas (KPAs) and Key Performance Indicators (KPIs) (used for validation within WP7).

We have applied the stringent methodology / time plan covering the whole duration of T2.2, meaning M3-M10, summarized in Figure *2*.

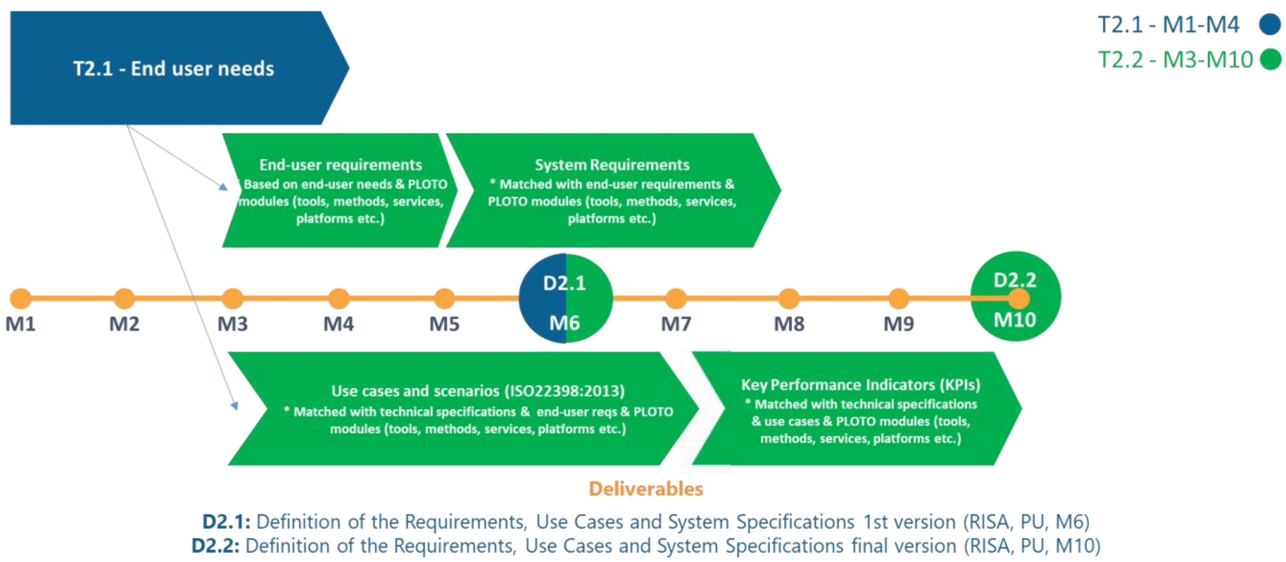

Figure 2: Task 2.2 methodology

More specifically, based on the end-user needs, as they were described in T2.1, in T2.2 we will identify the end-user requirements (specific methodology used is presented in Section 2.2.1). At the same time, we will define the PLOTO modules (specific methodology used is presented in Section 2.2.2) and describe the use cases - scenarios (specific methodology used is presented in Section 2.2.3). In the respect of this Task, the system requirements will be also identified, and these should be matched with the end-user requirements; as well as with the PLOTO modules (tools, methods, platforms etc.). Finally, the Key Performance Areas and Indicators list will be specified.

In this initial deliverable of WP2 (D2.1, M6) the following information related to T2.2 will be presented: (a) produce a detailed specification of PLOTO end-users' requirements (results presented in Section 4); (b) describe the PLOTO platform's modules (results presented in Section 0) and; (c) define initial information collected from end-users and supports the definition of the use cases and scenarios that will be used to validate the PLOTO platform in WP7 (results presented in Section 0). For each one of the aforementioned sub-tasks, a specific methodology was identified and used (as described in the following Sections). Complementary, in respect of this Task and to better meet the objectives of this Deliverable, an initial WP2 online workshop was organized (17/01/2023) which aim and results will be presented below.

2.2.1. PLOTO end-user requirements definition methodology

For the collection and description of the end-user requirements, a template was created, shared and agreed upon with partners. This template (Figure 3) was based on ISO 29148:2018 (ISO, 2018) and consists of several sheets, which are described below:

- Sheet 2 "User Requirement Types": The User Requirement Types list and their description/definition. This list will be used in Sheet 4.

- Sheets 3-7 "User Requirement per Type": The Users Requirements (per type) identification and description will be provided here. These shall be filled in by all PLOTO project end-users in coordination with technical providers and other partners.

Moreover, guidelines for filling-in the requirements were provided, as described below:

- Requirements are mandatory binding provisions and use 'shall'. Avoid using terms such as 'shall be able to'.
- Use positive statements and avoid negative requirements such as 'shall not'.
- Use active voice: avoid using passive voice, such as 'it is required that'.
- Non-requirements, such as descriptive text, use verbs such as 'are', 'is', and 'was'. It is best to avoid using the term 'must', due to potential misinterpretation as a requirement.
- Statements of fact, futurity, or a declaration of purpose are non-mandatory, non-binding provisions and use 'will'. 'Will' can also be used to establish context or limitations of use.
- Preferences or goals are desired, non-mandatory, non-binding provisions and use 'should'. They are not requirements.
- Suggestions or allowances are non-mandatory, non-binding provisions and use 'may'.

Ploto

Deployment and Assessment of Predictive modelling, environmentally sustainable and emerging digital technologies and tools for improving the resilience of IWW against Climate change and other extremes

Task 2.2 - Specification of System Requirements, Use Cases, Scenarios Definition and KPIs

This questionnaire is related to T2.2 and will be used in order to support the collection of the user requirements, that should be considered during the design and development of the PLOTO platform .

This excel consists of several sheets, which are described below:
- Sheet 2 "Users Requirements Types": The Users Requirements Types list and their description/definition. This list will be used in Sheet 4.
- Sheets 3-7 "Users Requirements per Type": The Users Requirements (per type) identification and description will be provided here. These shall be filled in by all PLOTO's project's end-users in coordination with technical providers and other partners.

Guidelines for writing requirements:

— Requirements are mandatory binding provisions and use 'shall'. Avoid using terms such as 'shall be able to'.
— Use positive statements and avoid negative requirements such as 'shall not'.
— Use active voice: avoid using passive voice, such as 'it is required that'.
— Non-requirements, such as descriptive text, use verbs such as 'are', 'is', and 'was'. It is best to avoid using the term 'must', due to potential misinterpretation as a requirement.
— Statements of fact, futurity, or a declaration of purpose are non-mandatory, non-binding provisions and use 'will'. 'Will' can also be used to establish context or limitations of use.
— Preferences or goals are desired, non-mandatory, non-binding provisions and use 'should'. They are not requirements.
— Suggestions or allowances are non-mandatory, non-binding provisions and use 'may'.

[Condition] [Subject] [Action] [Object] [Constraint of Action]

EXAMPLE: When signal x is received **[Condition]**, the system **[Subject]** shall set **[Action]** the signal x received bit **[Object]** within 2 seconds **[Constraint of Action]**.

Or

[Condition] [Subject] [Action] [Object] [Constraint of Action]

EXAMPLE: At sea state 1 **[Condition]**, the Radar System **[Subject]** shall detect **[Action]** targets **[Object]** at ranges out to 100 nautical miles **[Constraint of Action].**

Or

[Subject] [Action] [Constraint of Action]

EXAMPLE: The Invoice System **[Subject]** shall display pending customer invoices **[Action]** in ascending order of invoice due date **[Constraint of Action].**

Figure 3: PLOTO end-users' requirements definition template (1)

To effectively and efficiently collect the required information, and based on ISO 29148:2018 (ISO, 2018), the requirements were grouped in the following categories:

- Functional Requirements (FR): Functional requirements describe the **system or system element functions or tasks to be performed by the system**. Performance is an attribute of a function. A **performance** requirement alone is an incomplete requirement. Performance is normally expressed quantitatively.
- Non-Functional Requirements (NFR): Include several 'ilities' in requirements, f**or example: transportability, survivability, flexibility, portability, reusability, reliability, maintainability,**

and security. Quality requirements (e.g., "ilities") should be identified prior to initiating the requirements activities. This should be tailored to the system(s) being developed. As appropriate, measures for the quality requirements should be included as well.

- Interface Requirements (IR): Interface requirements are the definition of **how the system is required to interact with external systems (external interface)**, or **how system elements within the system, including human elements, interact with each other (internal interface)**. External interface requirements state characteristics required of the system, software or service at a point or region of connection of the system, software or service to the world outside of the item. They include, if applicable, characteristics such as location, geometry and what the interface is able to pass in each direction.
- Usability Requirements (UR): Provide the basis for the design and evaluation of systems to meet the user needs. Usability/Quality-in-Use requirements are developed in conjunction with, and form part of, the overall requirements specification of a system. The dimensions of usability as recommended by ISO/IEC TR 25060:2010 and ISO 9241-11:2018 are the following: **effectiveness** (accuracy and completeness with which users achieve specified goals); **efficiency** (resources expended in relation to the accuracy and completeness with which users achieve goals); **satisfaction** (extent to which the product or service meets the user's needs and expectations).
- Process Requirements (PR): These are stakeholder, usually acquirer or user, requirements. Process requirements include **compliance with national, state, or local laws, including environmental laws, administrative requirements, acquirer/supplier relationship requirements and specific work directives.**

For each one of the aforementioned categories, several fields that should be filled in by end-users were identified, as described below:

- **UID:** Unique ID for each requirement.
- **Version No:** If a requirement changes, create a new row, that will have the same UID and another version number.
- **Requirement Type:** Requirement type is always the same in each sheet.
- **Requirement Category:** Main functions or tasks to be performed by the system.
- **Requirement Name:** Requirement name.
- **Requirement Description:** Requirement description.
- **Priority:** Prioritisation of requirements, using the MOSCOW technique (Must-have, Should-have, Could-have, Will not have).
- **Owner:** Partner that provided this requirement.
- **Relative WP:** WP that this requirement is related to.
- **Relative module:** Module name that this requirement is related to.
- **Relative Use Case/Scenario:** Relevant use-case/scenario that this requirement is related to.

In Figure 4, an indicative user requirement collection sheet is displayed.

Functional Requirements:

Functional requirements describe the system or system element functions or tasks to be performed by the system. Performance is an attribute of function. A performance requirement alone is an incomplete requirement. Performance is normally expressed quantitatively.

UID	Version No	Requirement Type	Requirement Category	Requirement Name	Requirement Description	Priority	Owner	Relative WP	Relative module	Relative Use Case/Scenario
Please insert a Unique ID for each requirement.	If you make any change at a requirement, please create a new row, that will have the same UID and another version number.	The requirement type is always the same in each sheet.	Please identify the main functions or tasks to be performed by the system.	For each category identify the relevant requirements and give them a name.	Please describe the requirement.	After having identified a requirement please prioritise them, using the MOSCOW technique (Must-have, Should-have, Could-have, Will not have).	Please provide the partner that provided this requirement.	Please name the WP that this requirement is related to.	Please provide the module name that this requirement is related to.	Please provide the relevant use-case/scenario that this requirement is related to.
FR-1	1.0	Functional Requirements								
FR-2	1.0	Functional Requirements								
FR-3	1.0	Functional Requirements								

Figure 4: PLOTO end-users' requirements definition template (2)

2.2.2. PLOTO modules definition methodology

The next critical step is the PLOTO modules identification and description. To coordinate technical partners; effectively and efficiently collect the required information, a template for the modules' definition was created (Figure 5).

Ploto

Deployment and Assessment of Predictive modelling, environmentally sustainable and emerging digital technologies and tools for improving the resilience of IWW against Climate change and other extremes

Task 2.2 - Specification of System Requirements, Use Cases, Scenarios Definition and KPIs

This questionnaire is related to T2.2 and will be used in order to support the identification and description of PLOTO modules. All technical providers shall fill it in with the relevant to their module information.

UID	Module Name	Partner Responsible	Main Contact (Name and Email)	Module Description	Module Components	Sources	Input Data	Output	Consumer	Tasks involved	Added Value	Other Information
Unique ID	Provide the complete name of the module.	Provide the name of the partner responsible for the module.	Provide the name and email of the main contact for the specific module.	A description about the aim and main characteristics of the module. Please answer to the question: What will the module do in the PLOTO platform?	Please list the components that the module consists of and describe their aim, as well as theis interrelationship(s).	List the modules/components that provide data or any other input to the described module.	Describe the input data needed for the module to perform its regular operations.	Describe the expected outcome of this module.	List the components/modules that feed from the activities or data produced by the described module.	List the PLOTO tasks where the described module participates.	In which sense this module adds a value to the project in general or to a specific task of the project?	Any information that can help to better understand the module (e.g., diagram, workflow, etc.).
1												
2												
3												
4												

Figure 5: PLOTO modules definition template

More specifically, the template consists of two (2) main parts that will be filled in gradually.

The first part is related to the description of the Module and partners were asked to fill in the following details per module:

- **UID:** Unique ID for each module.
- **Module Name:** Complete name of the module.
- **Partner Responsible:** Name of the partner responsible for the module.
- **Main Contact (Name and Email):** Name and email of the main contact for the specific module.
- **Module Description:** A description about the aim and main characteristics of the module (What will the module do in the PLOTO platform?).
- **Module Components:** Components that the module consists of and describe their aim, as well as their interrelationship(s).
- **Tasks involved:** PLOTO tasks where the described module participates.
- **Added Value:** In which sense this module adds a value to the project in general or to a specific task of the project?

Having identified the aforementioned information, partners were asked to discuss and fill in the second part that is related to the identification/description of the data produced and consumed by each module:

- **Sources:** Modules/components that provide data or any other input to the described module.
- **Input Data:** Input data needed for the module to perform its regular operations.
- **Output:** Expected outcome of this module.
- **Consumer:** Components/modules that feed from the activities or data produced by the described module.
- **Other Information:** Any information that can help to better understand the module (e.g., diagram, workflow, etc.).

The results collected are presented in Section 0.

2.2.3. PLOTO use-cases and scenarios definition methodology

PLOTO Consortium and Grant Agreements have well defined and described the need for the Use Cases as well as its objectives. Also, through these, the base of support and commitment from partners (technical, end-users etc.) to ensure the appropriate organisational involvement and commitment of resources has been secured.

Use Case and Scenario definitions are complicated and incremental processes, that are built from the compilation and processing of input required from various partners (end-users, technical partners, technology providers and researchers). Use case leaders, in close cooperation with relevant partners, should design and develop the Use Cases and Scenarios based on the needs analysis and the scope of the project. To support this, bi-weekly and ad-hoc teleconferences as well as Consortium meetings and site surveys were organised with partners involved. The aim of these meetings was among others to manage and synchronise activities; record partners' needs and requirements, as well as discuss and decide on issues related to the system deployment.

Moreover, comprehensive, and organized documentation shall be prepared to ensure an accurate account of the demonstrations is preserved. This in turn allows end-users and partners to better manage demonstrations; leverage past documentation to support future trials; and ensure that all critical issues, lessons learnt, and corrective actions are appropriately captured to support improvement efforts. In general terms, Use Cases and Scenarios shall:

- be a plausible story with factual supporting information,
- be representative of the themes chosen,
- be described and structured consistently and logically,
- be related to a specific time horizon and policy field and,
- take account of existing policy on measures for the various stages in the business chain.

Therefore, to better describe each PLOTO Use Case, the following information shall be collected:

- the location, landscape and environmental conditions of each PLOTO Use Case,
- the relative legislation, the operations' executed and stakeholders involved (of each PLOTO Use Case),
- the description and definition of data and assets used at each PLOTO Use Case,
- the exposure of each Use Case to hazards addressed by PLOTO, and
- current adaptation and mitigation measures applied to each PLOTO Use Case.

Each of the Use Cases must be unique, cover its potential Use Case scope and can have variations, namely Scenarios. Scenarios can be developed by thinking up several sufficiently distinctive variants that could differentiate the Use Case. Scenarios may differ, for example, in scale and intensity of the events, geographical location, likelihood, technologies used and possibly other circumstances. Scenarios shall be structured in a logical, readily accessible way to the exercise players and in doing this, the following information shall be collected and analysed (by considering the aforementioned identified information for each Use Case):

- relevant details of the hazards/events, assets and technologies (including legacy), as well as stakeholders that will be used in each scenario,
- aim and objectives of each Scenario will be described,
- the story and events of each scenario,
- the way that PLOTO platform, assets, systems and technologies (including legacy) will be used and,
- the stakeholders' involvement shall be described, and relevant details shall be provided (if needed).

The Use Cases and Scenarios description shall be shared, agreed, and validated with partners. This validation requires the help of specialists and experts to verify and approve the accomplished work. In Section 6, the information collected with regards to the Use Cases definition is presented.

2.2.4. 1st WP2 online workshop

In the respect of WP2, the 1st WP2 online workshop was planned and held on Tuesday 17th January 2023 (13.00 - 15.00 CET) and all partners participated. The aim was to create a space in which partners had the chance to present results, discuss questions, brainstorm ideas, identify problems, make decisions on the end-users' needs and scenarios, PLOTO modules, end-users' requirements and data identification. The agenda of the meeting is presented in Table 2.

Table 2: 1st WP2 online workshop agenda

WP2 1st Online Workshop Tuesday 17th January 2023 (13.00 – 15.00 CET)		
Time (CET)	**Presentation Topic**	**Presenter**
13:00-13:05	Welcome, meeting objectives and agenda (Duration: 5')	RISA
13:05-13:35	Presentation of User Needs (methodology and results) (Duration: 30')	BME
13:35-14:05	Presentation of Use Cases (Duration: 30' total – 10' presentation for each Use Case)	Use Case A: AFDJ/UDG/RRT (10') Use Case B: BSZL/MAV/RSOE/BME (10') Use Case C: SPW MI/ULiege (10')
14:05-14:25	Presentation and identification of PLOTO modules and technologies (Duration: 20')	NTUA
14:25-14:45	Presentation and identification of data to be used in each PLOTO Use Case (Duration: 20')	AUTH
14:45-14:55	Presentation of User Requirements and Use Cases identification templates (Duration: 10')	RISA
14:55-15:00	Conclusions (Duration: 5')	RISA

During the meeting, several issues related to the PLOTO project and towards the aim of this Deliverable have been discussed. Moreover, the meeting supported and enhanced the creation of a common understanding of the IWW operation, needs, requirements, as well as of the PLOTO technologies. After the meeting, partners decided to arrange dedicated meetings with each Use Case partners, to further discuss and analyse the specifics to the Use Case needs and solutions.

3 PLOTO end-user needs and good practices analysis of adaptation and mitigation measures

3.1 Description of IWW system and its operation

An inland waterway is a navigable channel used to transport goods, materials, or other movable objects. Inland waterways consist of rivers, lakes, canals, and backwaters. Rivers and lakes are natural waterways, whereas canals and backwaters are artificial (UNACADEMY, 2022). Inland waterway transport plays an important role for the transport of goods in Europe, where 13 member states have an interconnected waterway network. More than 37,000 kilometres of waterways connect hundreds of cities and industrial regions. Compared to other modes of transport that are often confronted with congestion and capacity problems, inland waterway transport is characterised by its reliability, energy efficiency, and major capacity for increased exploitation (European Commission, 2022). Inland waterway transport also ensures a high degree of safety, in particular when it comes to the transportation of dangerous goods.

Several operations get planned, organised and executed in an inland waterway, so as to assure that processes are driving value. According to the normative literature, the operations of water transport can be divided into three segments (as displayed in Figure 6 below):

- IWW infrastructure management covers the development and maintenance of infrastructure elements supporting waterborne transport and water management including dikes and flood gates.
- Traffic management covers the movement of vessels between ports, including route planning, navigation, and arrival time prediction.
- Logistics service management covers the actions at ports, such as loading, unloading, and storage.

IWW operation must be efficiently integrated into the transport system because it does not offer door-to-door services. Therefore, the supply chain management is needed to facilitate integration and cooperation with other transport modes. Supply chain management helps to ease the adverse effects of multimodal transport services. Since the operational activities have strong influence on each other, the need for efficient communication arises. Thus, the importance of information systems and services are high in waterborne transport. The information layer helps to connect the stakeholders of the system and supports efficient communication and high-quality information services, such as real-time vessel monitoring.

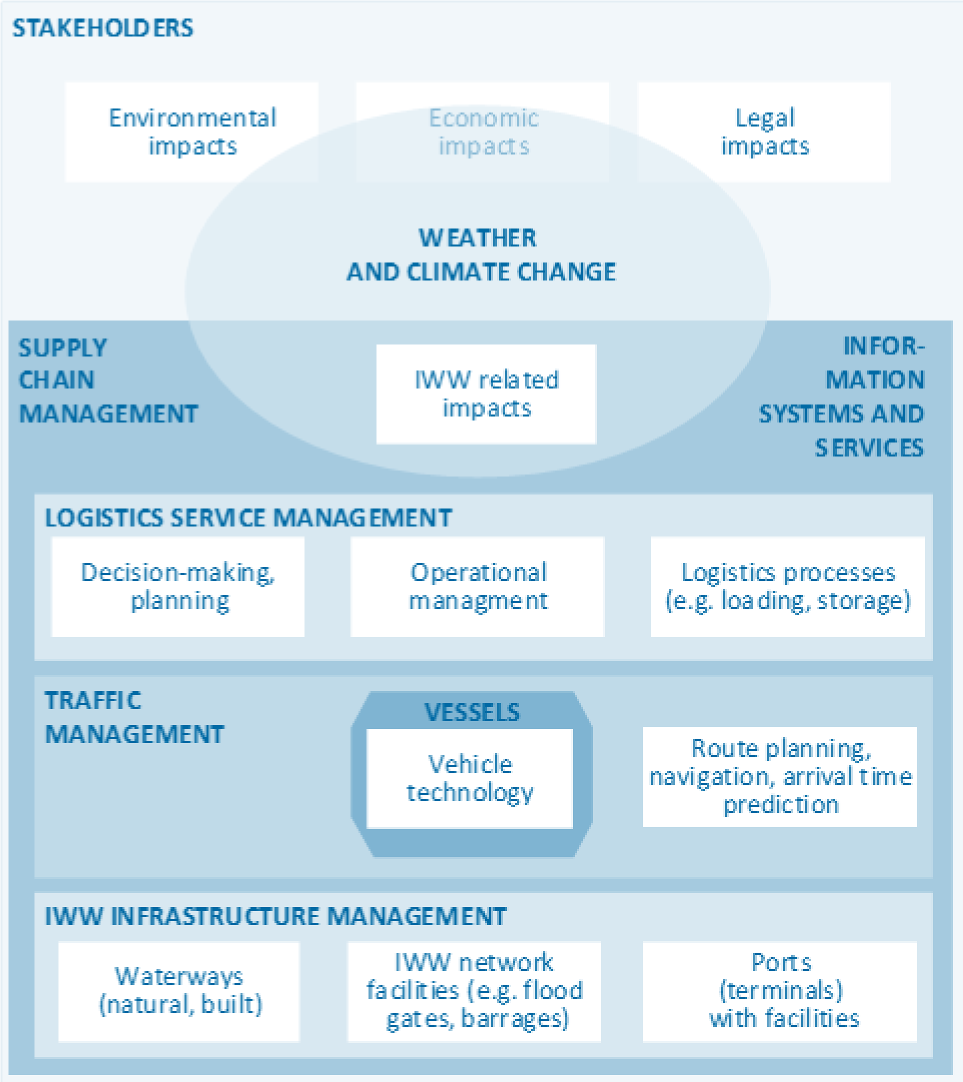

Figure 6: IWW system and its operation

The main stakeholders involved in the IWW operations execution and management, which should cooperate efficiently and effectively are the following:

- clients,
- vessel operators,
- port operators,
- logistics service companies, and
- information service providers.

Based on end-users' experience, and the normative literature, such as the PIANC report of 2020 (PIANC, 2020) and INSPIRE knowledge base (European Commission, 2022), IWWs conduct the main operations described above in three main zones and several main and sub-areas, as described below (Figure 7):

- The IWW zone (watercourse of the IWW) has mainly a navigation area that is located in the IWW and is related to the vessels' watercourse in the river:
- The IWW port related zone has a navigation and a berthing area; is located both in the river and the riverside; and is the point where the port authority starts controlling a vessel:
- The dry port zone, which structure and description is based on the terminal type that is hosted in and operates at this zone. At this zone, there exists a quay area, which is a platform lying alongside or projecting into the water for loading and unloading vessels, parking areas, gates etc. The rest of the areas depend on the terminal type.

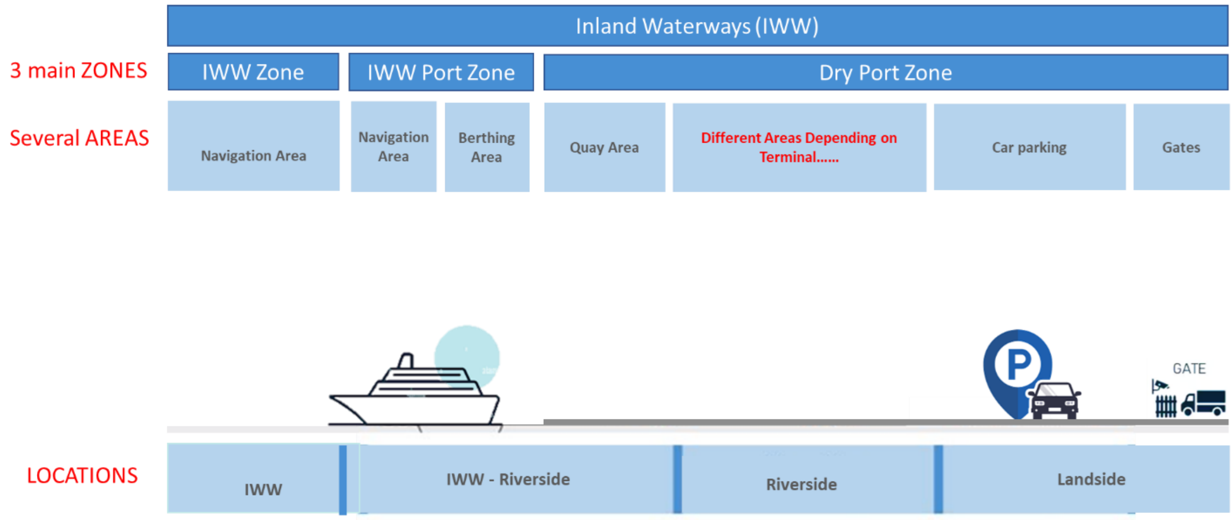

Figure 7: IWW zones and areas

Each port can have different terminals, which are defined as any location where freight (general and bulk cargo) and passengers either originate, terminate, or are handled in the transportation process (Figure 8). The two main categories of cargos carried, are general (carried in defined load units) and bulk cargo (carried in any quantity). Ports and inland waterways (depending on the terminal type) require specific facilities and equipment to meet their aim and execute effectively and efficiently their operations (Rodrigue, 2020).

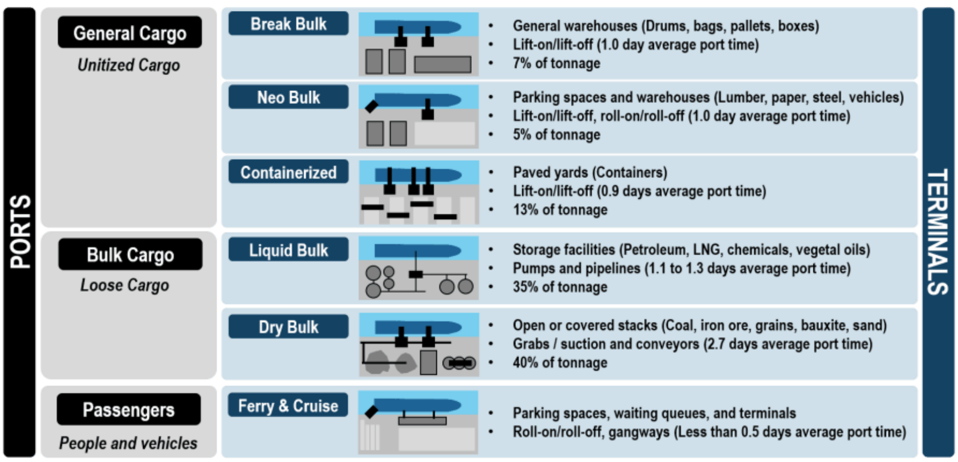

Figure 8: IWW ports and terminals (Rodrigue, 2020)

The areas and the operations executed in each zone of a port with a general cargo terminal are the following (Figure 9):

- The IWW zone (watercourse) with its navigation area.
- The IWW port related zone with its navigation and berthing areas.
- The dry port zone, where a quay area exists (platform lying alongside or projecting into water for loading and unloading vessels), as well as parking areas, gates etc. The quay area (of the general cargo area) can have different crane's types to load and unload the vessels. Next to this area, there is the riverside transport area, where containers are transported from the riverside to the yard. The yard is the core element in operating a cargo terminal, that can have different layouts as well. Next to this, there is the landside horizontal transport where the containers are distributed to and from other nodes of transport. Then we can have truck and train areas, parking spaces and finally the port's gate.

To support their operations, IWW ports invest and maintain several assets such as piers, basins, stacking or storage areas, warehouses, cranes, stacking yards serviced by gantry cranes, as well as vehicles used to move containers around the terminal, such as straddle carriers. In Figure 9, indicative assets operating in a general cargo terminal are identified and displayed.

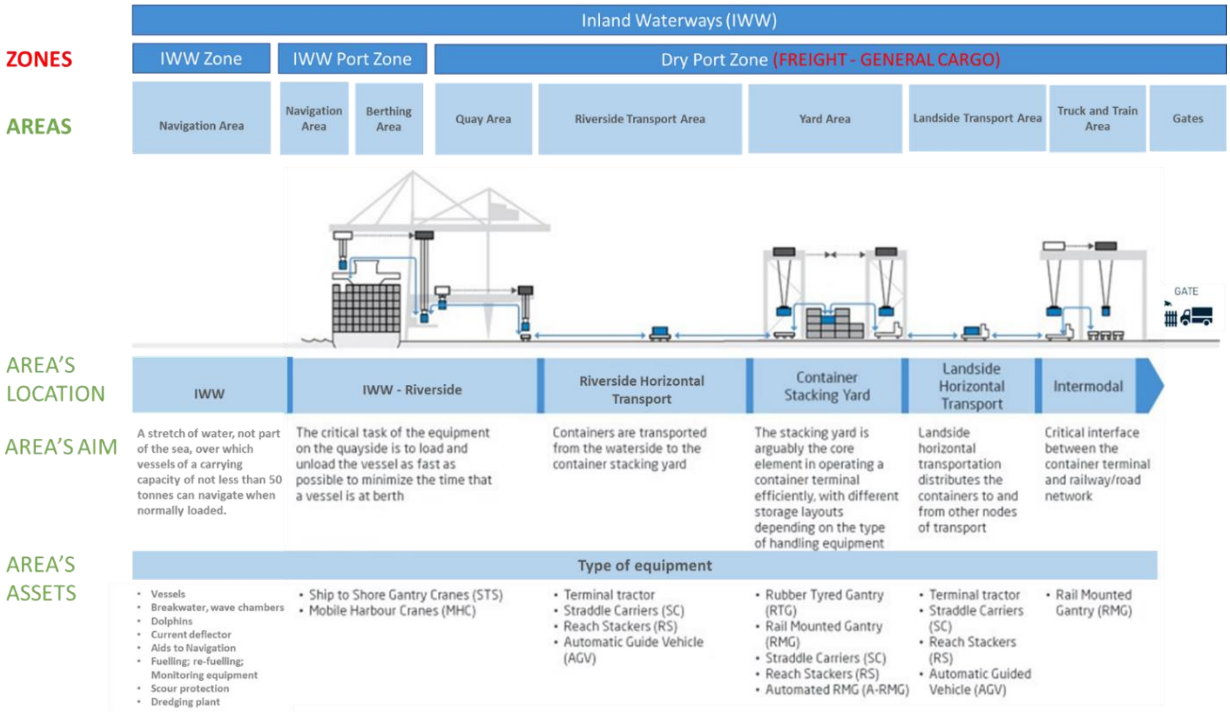

Figure 9: IWW zones and areas (general cargo terminal)

IWWs are influenced by weather and climate change. The impacts can be identified on multiple levels: environmental, societal, economic, and legal impacts. On the one hand, the stakeholders have been facing the challenges generated by the inherently intermittent weather and developed proper measures to mitigate the adverse effects. The key is the reliable and high-quality forecast to give the proper answers in time. On the other hand, climate change has negative effects on the conditions of IWWs and offsets the transport system into a new pareto optimum at the expense of waterborne transport. The challenge is to reveal and identify the long-term effects of climate change and develop the proper answers to them. Currently, the biggest challenge is the long period of draughts which hinders waterborne transport for several months on natural IWWs.

3.2 Literature review

Inland Waterways play an important role in freight transportation and is one of the most significant transport systems together with road and rail transport (Christodoulou, Christidis, & Bisselink, 2020). IWWs are considered to be a very reliable mode but can be more vulnerable to climate change than rail or road transport, because of the reliance of the river navigation on water levels. At European level, several regulations deal with IWW, and some selected examples of these regulations are presented in the following paragraphs.

Regulation (EU, Romania, Belgium, and Hungary)

Regulation **(EC) No 718/1999** on Community-fleet capacity policy to promote IWW transport covers vessels that transport goods commercially. It states that an Inland Waterways Fund should be created in EU countries with a fleet tonnage of over 100,000 tonnes. Regulation **(EU) No 546/2014** amends Regulation **(EC) No 718/1999**, encouraging the upgrade of vessels to improve working conditions and safety, innovation in respect of vessels and their improved environmental performance among various topics (Rules for promoting inland waterway transport in the EU, 2020).

River Information Services (RIS) has been defined as the harmonised information services to support traffic and transport management in inland navigation, including, wherever technically feasible, interfaces with other transport modes. RIS are open for interfacing with commercial activities and comprise of several services such as: fairway information, traffic information, traffic management, calamity abatement support, information for transport management, statistics, customs services, waterway charges, port dues etc.

The Directive 2005/44/EC on harmonised RIS on the EU's IWWs establishes rules on their use. This Directive applies to the implementation and operation of RIS on **all inland waterways of the Member States of class IV and above,** which are linked by a waterway of class IV or above to a waterway of class IV or above of another Member State, including the ports on such waterways as referred in Decision No 1346/2001/EC of the European Parliament and of the Council of 22 May 2001 amending Decision No 1692/96/EC as regards seaports, inland ports and intermodal terminals as well as project No 8 in Annex III. These rules are designed to ensure the safety, efficiency, and environmental friendliness of IWWs in the EU.

RIS includes geographical, hydrological, and administrative data on waterways; data relevant to navigation in the short, medium, and long term; action in the event of an accident; statistics, customs services, waterway charges and port dues (Safe and efficient river transport: river information services, 2016). **Regulation (EC) No 414/2007 defines guidelines for RIS planning, implementation, and operation, including RIS architecture (i.e., stakeholders, service providers, users, objectives, tasks, and applications) and information for transport logistics** (Inland waterways — river information services (RIS), 2020). The aim of this regulation is to increase competitiveness in the sector; optimise the use of existing inland waterway infrastructures; improve safety and security in waterway transport; and reduce the sector's negative environmental impacts.

Regulation (EU) 2018/974 (on statistics of goods transport by IWW - codification) and Regulation (EC) 1365/2006 (on statistics of goods transport by IWWs) complement each other and are collected in the Reference Manual on Inland Waterways Transport Statistics. It provides the description of the structure of the dataset, the classifications to be used, the definition of the statistical units and variables as well as data transmission and integration process instructions. Finally, it presents the currently applied quality checks and dissemination means available for IWW statistics.

In Hungary, vessels transporting dangerous goods on the river Danube entering the country and/or starting/ending a voyage along the Hungarian Danube section are obliged to report via Very High Frequency (VHF) channel 22 (or phone, fax, email) to the shipping authority according to the notice to skippers 006/Du/2013 based on the ADN regulation (Eurostat, 2022). Moreover, **act XLII/2012 on waterborne transport** defines the public and municipal tasks of waterborne transport, the personal and material conditions for carrying out the activity and the management of waterborne transport in order to develop environmentally friendly and energy-saving water transport and to achieve the transport policy goals, as well as the integration of shipping activities into the unified international transport system, and the international agreement in order to fulfil the stated obligations (Hungarian Parliament, 2000). The Hungarian Ministry of National Development (NFM) **57/2011 (XI. 22.) decree on water transport regulations** determines the rules of water transport in Hungary (Ministry of National Development, 2011). The detailed rules for the investigation of maritime accidents and incidents are laid down in **Decree 77/2011 (XII. 21.)** (Ministry of National Development, 2011). In addition to official regulations the Notices to Skippers are also very important information sources for the port and vessel operators (Notices to skippers, n.d.).

Romania uses the Government **Ordinance no. 22/1999** regarding the administration of ports and IWWs, the use of the naval transport infrastructure belonging to the public domains as well as the naval transport activities in ports and IWWs. Also, the **Ordinance no. 42/1997** establishes specific rules applicable to maritime and IWWs transport, the organization of the institutional system in this area and the bodies forming part of the system, specific rules for the safe development of navigation as well as specific rules for ships, their staff and staff conducting shipping activities, related and support activities. The Ministry of Transport (MT) of Romania is the state authority for naval transport, which elaborates and coordinates the policy and development of the naval transport system in Romania. It ensures the fulfilment of the obligations deriving from the agreements and international conventions to which Romania participates, such as: (Cristea and Partners Law office); (Romanian Parliament, 2002).

In Belgium, the Belgian Royal Decree of 24/09/2006 regulates the navigation of vessels on IWW networks. For most waterways, there are special regulations that include site-specific operational provisions (Nzengu, et al., 2021). In the Walloon region, which is under consideration in PLOTO, transport on the IWWs is regulated by the division of mobility and infrastructure (MI) being part of the public service of Wallonia (SPW). Shipping and navigation are managed at the regional level in Belgium, and in Wallonia it is governed by a several regional regulations authored by SPW-MI reflecting the specifics of management of the IWWs in the region. Most recently the Regional Strategy on Mobility (Stratégie Régionale de Mobilité) was published by SPW-MI covering all parts of transport. It is split into a section on the mobility of people (SPW Mobilité et Infrastructures, 2019), and a section on the mobility of goods (SPW Mobilité et Infrastructures, 2020). The Regional Strategy on Mobility reflects the vision FAST 2030, which was issued by the Belgian ministry of mobility, adopted by the Walloon government in October 2017, and ultimately specified by the Regional Strategy on Mobility. The overall goal of this vision is to reduce the greenhouse gas emissions by 35% by 2030 compared to the level of 2005. To the emissions under consideration, transport contributes by 38 %. Unlike other sectors, the emissions of transport even increased during the past years in Wallonia, moreover, it is estimated that the overall amount of goods to be transported may grow in the Walloon region by up to 19 % by the year 2040. It is important to recognize that the largest amount of carbon emissions due to transport in the Walloon region is attributed to transport by road vehicles. Increasing the fraction of goods shipped on the IWWs may be an appropriate measure to reduce greenhouse gas emissions, hence contributing to the targets of FAST 2030. This highlights the growing importance of the IWWs and its related infrastructures in the Walloon region, as well as the need for an in-depth assessment of resilience of the IWWs against hydrological extremes.

Weather impacts and resilience (including climate change, and sustainability)

Inland waterways are sensitive to climate change as river navigation depends on water levels. Droughts can severely disrupt inland waterway navigation services by reducing water levels either to a level that is completely unseaworthy or to a level that obliges operators to reduce vessel loads. In addition to water levels, **ice formation** can also disrupt inland waterway operations, especially in slow-flowing rivers; for example, navigation on the Danube was interrupted for several days in the winter of 2005 and 2006 due to ice formation (Scholten & Rothstein, 2016). However, ice has limited effects in terms of duration or frequency, which are expected to decrease further due to projected increases in temperature in the (medium to long-term) future. **Higher than normal water levels** may affect inland navigation, especially if they exceed critical limits set by infrastructure, while stronger and more adverse currents may increase the likelihood of accidents and travel times. While the uncertainties of climate projections should not be ignored, **the shipping sector tends to benefit from global warming**, meaning that European inland waterways could be one of the few sectors where climate change **could have a negligible or even positive impact** under the 'worst-case' RCP8.5 emissions scenario. Most climate models simulate a time shift in the water discharges in the main inland waterways, the Rhine, and the Danube, due to an earlier start of the melting season (Christodoulou, Christidis, & Bisselink, 2020). Increased discharges are caused by more precipitation in general and/or more extreme single precipitatation events and/or due to increased melting of glaciers.

Constructed waterways increase the peaks of floods because the retention capacities of river are reduced by construction due to depletion of natural shores / less space for meandering, less area for flooding. So, there is quite some potential for increasing flood prevention linked to IWWs. In general, IWWs are destructive for natural habitats. They also tend to not improve the chemical quality of inland waters.

Climate change can exacerbate the environmental problems through changing temperatures, reduced precipitation, increased adverse effects of excessive nutrient discharges, and the introduction of invasive species. **The creation of a complete pan-European inland waterway network requires the closure of the so-called missing links**. However, this could cause serious damage to both aquatic and terrestrial ecosystems through lost habitats, increased flows and erosion, degraded ecosystems, and loss of ecosystem services. However, a well-designed expansion of the inland waterway network according to the modified Ecological Limits of Hydrologic Alteration (ELOHA) method and the development of a multimodal transport system can offer a viable trade-off for a well-developed inland waterway network in Europe (Némethy, Ternell, Bornmalm, Lagerqvist, & Szemethy, 2022).

Extreme weather events relevant to IWW transport are low-water events (drought), high-water events (floods), as well as ice occurrence. Long periods of low-water levels may increase the costs of transportation, due to the limitation of the cargo capacity. On the other hand, heavy rainfall may result in flooding and damage to the IWW infrastructure. Besides that, ice may cause damage to the infrastructure as well as the suspension of navigation (Schweighofer, 2014).

Climate change may aggravate environmental problems through changing temperatures, reduced precipitation, enhancing the adverse impact of excess nutrient discharge, and the entry of invasive species (Némethy, Ternell, Bornmalm, Lagerqvist, & Szemethy, 2022). Although scientific opinions on the effects of climate change predict a long-term decrease in rainfall, hydrological disasters may become more frequent. Disasters of hydrological origin generally mean floods, flash floods, and droughts, and extraordinary events caused by sudden, heavy rainfall (for example traffic chaos or damage caused by drainage malfunction). In Hungary, excess water and lack of water can cause hydrological damage even within a calendar year of which the year 2018 is a good example (Kirovné Rácz and Márton, 2020).

In respect to the low water level, a report (Scholten & Rothstein, 2016) showed, that inland navigation still is an important transport mode, along the Danube as well as in other European regions. Especially in Romania, inland navigation still has a share of more than 20% and rising in total transport. However, inland navigation depends strongly on the good conditions of its infrastructure. These good conditions are limited mainly by two main factors: waterway narrowings (stenosis), and weather. In addition to other minor factors such as laws, human built structures, as well as the speed of travel. One of the targets of this report is to estimate the economic impact of low water periods. All the factors named above as well as the freight prices charged for connections along the Danube are used. With the help of previous regression equations, an estimation of the total expenses for transport via inland navigation for several years is made possible. The yearly and seasonal variability is identified as well as the additional expenses due to water levels below 280cm. But additional expenses are not the only impact of changing water levels on inland navigation. Another is that while the demand for transport stays at the same level, sometimes the water levels are not sufficient to use the full capacity of the fleet.

Climate change can have negligible or even positive impacts on the European IWW sector. An increase of the discharge levels would reduce the number of days with low water level benefitting the operations. As a result, the average annual economic benefits may increase. However, it cannot be generalized. Some sections of the network might be disrupted by droughts which will affect the transportation through specific routes (Christodoulou, Christidis, & Bisselink, 2020); (Schweighofer, 2014).

In order to access for the impacts of climate change Chrisodoulou & Demirel (2018) seek answers for some relevant issues such as; climate change effect on transport operations, significance of the anticipated changes, locations of the most severe impacts that will take place in Europe, and vulnerability measures of different modes to climate change. Among several climate stressors, sea level rise, storm surges, floods, wind gusts and droughts are selected considering the relatively high impacts they have (Christodoulou & Demirel, 2018). Regarding wind, higher wind gust speeds are projected in the middle and end of the century. Seaports are exposed to storm surges and sea level rise by default and are vulnerable to flooding. Climate change is expected to have more severe impacts in northern Europe. In total, 852 ports face the risk of inundation in 2080 and the number of seaports to be exposed to inundation levels higher than 1m is projected to increase by 80% from 2030 to 2080. Inland waterways are vulnerable to climate change because river navigation depends on water levels. Droughts have the most disruptive impacts for inland waterways because low water levels impose limitations to navigation services.

As it is not assured that extreme weather conditions may exhibit trends, there is a need to improve resilience of IWW to be prepared for adverse events in the present and future (Mika and Farkas, 2017). Actors involved have a role, right and obligation in adapting to the effects of climate change, including extreme situations, from citizens to professional disaster management agencies and those involved in national defence (Kirovné Rácz and Márton, 2020).

A resilience study aims at proposing rules for maintaining the operation of an inland navigation network during extreme conditions such as floods and droughts. Stable and adaptive resilience rules should be suggested; stable to resist change and adaptive to accompany that change. Understanding the functioning and needs of the network is an important step to determine these rules (Desquesnes, Nouasse, Lozenguez, Doniec, & Duviella, 2016).

Some practices and tools have been developed to support understanding the functioning and needs of the network. Software has been designed to model any configuration of inland networks, to generate scenarios (e.g., flood, drought), and to optimize the water management. Normal, low, and high navigation levels are mapped, and the flow of water and demand for shipping between sections of the inland waterways are simulated (Desquesnes, Nouasse, Lozenguez, Doniec, & Duviella, 2016). It is possible to show the trends of the anthropogenic impacts, e.g., the development of the water utility works and their impact on the inland excess water situation in the settlements. The implementation of complex approaches gets important in urban water management and rainwater management becomes necessary at individual and municipal levels (Priváczkiné Hajdu, 2018). Also, the main European IWW corridors and their branches had their ecological viability assessed. The environmental viability of such network depends on the right assessment of ecosystem services and protection of biodiversity. A model structure for landscape conservation, green infrastructure development, water replenishment, and ecosystem reconstruction was proposed recently, considering a sustainable combination of multimodal IWW and rail transport (Némethy, Ternell, Bornmalm, Lagerqvist, & Szemethy, 2022). In addition, some companies are researching and developing new ship designs which are more robust to extreme weather conditions, for example, catamarans that are ships with shallower draft (Chowdhury, 2018).

Global warming increases the need for water resource management. The Danube is both a drinking water base and a transport route and thus planning is necessary based on objective reasoning in the interests of sustainability. Increasing transport volumes clearly increases the environmental pressure. This could lead to forward-looking changes by shifting to shipping with large capacity reserves. We need to allocate additional resources to support the central role of water and rethink the sources, amounts, and allocation mechanisms of financial instruments to ensure the economic viability of the '2030 Agenda for Sustainable Development' (Horváth and Kozma, 2017).

Romania has set the following targets for the year 2030: (1) strengthen Romania's resilience and capacity to adapt to climate and natural disaster risks, (2) improve the capacity to react quickly to extreme weather events of high intensity, and (3) improve capacity on climate change mitigation and adaptation. With 245 km of coastline, including the Danube River and the Black Sea, Romanian authorities have noticed the reduction on water quality. Therefore, Romania has implemented the Marine Strategy Framework Directive (2008/56/EC) and is a party of the Black Sea Convention that aims to create protected areas of national and European interest on the coastal zone. Romania is the co-initiator of the European Union Strategy for the the Danube region, to protect and improve water quality, conserve biodiversity, and protect landscapes, soil and air quality (Firoiu et al., 2019).

IWW transport is energy efficient when compared to other modes due to its low level of greenhouse gas emissions and large freight transportation. Because of that, **IWW transport might help to achieve the Sustainable Development Goals and the European Union's goal of a climate-neutral economy by 2050**. Transferring part of the cargo currently transported on road to the IWW would lower external costs of climate change, noise, congestion, and advance safety. To improve these benefits, vessels could use alternative fuels (e.g., liquefied natural gas, hydrogen) and install new engines to comply with the strictest emission standards. A sustainable IWW transport targets lower environmental and economic costs during operation and developing works. Additionally, it promotes social equality and is resilient to climate change (Cavalcante de Barros, Bulhões de Carvalho, & Pinho Brasil, 2022); (Plotnikova, Vienažindienė, & Slavinskas, 2022).

Logistics (impacts on freight transport, and economic issues)

The impact of extreme weather conditions on IWW logistics depend on the waterway under consideration and the cargo transported. For example, **just-in-time and scheduled cargo deliveries are more sensitive to delays**. Unlike, bulk cargo, such as iron, is not significantly impacted due to larger stocks. Increased traveling time may be caused by high water level and high stream velocities when navigating upstream, or by low water levels and shallow sections where the resistance of vessels is also increased. **The limitation of cargo capacity in shallow water may force the exchange of large vessels to smaller ones as the latter are less affected.** As a result, costs for transportation are higher (e.g., due to fuel) (Schweighofer, 2014). Strategic alliances between IWW transport and other modes of transportmight be a solution when navigation is not possible. However, it has some limitations such as capacity limits of rail infrastructure and rolling stock, and high price level of road infrastructure (Ubbels, Quispel, Bruinsma, & Holtmann, 2012). To promote intermodal transportation, port authorities should take an active part in creating unique and cutting-edge multimodal logistics solutions for the shipping sector (Platform for multimodality and logistics in inland ports, 2015).

IWW transport has poorer conditions in term of maintenance and water level control in Eastern Europe than in Western Europe but its significance in goods delivery was relatively high until the 1980/1990s. However, it collapsed during the past two decades. The relative importance of technology change and economic restructuring for the current recession of navigation remains uncertain. The impact of the expansion of the EU is manifested by the increasing ratio of international goods transport. The future of IWW transport is entirely determined by two factors. One is how it can be integrated into the system of multimodal water transport (the combination of IWW/sea navigation would be the most optimal) and the other is how climate change will affect the already hardly navigable existing waterways (Erdősi, 2007).

The development of IWW transport is one of the long-term priorities of sustainable development of the EU. Through their connections in inland ports, IWW transport and railroads' cooperation can provide a sustainable transportation option in Europe. Because they serve as transition sites to other modes of transportation and are connected to logistical hubs, industrial zones, agricultural areas, or major consumer markets like urban areas, European inland ports are essential links in the multimodal transport networks. Desüpite, these potential benefits, some barriers should be overcome, such as: supply chain decision makers should decide together the operations and investments, consignment size, time for production and shipment, provision of infrastructure and information as well as collaboration with other transport operators, and policy making on various levels (Platform for multimodality and logistics in inland ports, 2015).

The Danube and Rhine-Main Canal, as well as Danube's tributaries represent the most important waterway in Europe. By analysing the available data which refer to the use of Danube waterway in the period starting from 1950, it was found that the **Danube waterway was used for the needs of traffic with different intensity**. By analysing the amount of freight transport, the number of passengers and heavy load in Danube harbours it is confirmed that the **Danube was intensely used as a waterway until 1990 and after that its popularity decreased**. Then, in the beginning of the 21st century, with the beginning of the all-inclusive initiative of the EU on promotion of inland water transport, some growth in the use of the Danube as IWW was noticed but that growth cannot be considered sufficient neither acceptable. The objective is to promote and improve sustainable water transport on Danube. Related activities mostly refer to modernization of the Danube fleet (with emphasis on use of biodiesel as a power generating fuel), construction of adequate infrastructure, development, and implementation of a unique information system on the Danube as well as many promotional activities (Mihic, Golusin, & Mihajlovic, 2011).

To protect Hungary against water damage, cross-border cooperation is extremely important which is based on the nearly 100-year-old water agreements with our neighbouring countries. In recent years, the countries have made significant interventions on the cross-border river basins changing natural surface runoff conditions. Ensuring water demand to create a good ecological status by WDF (Water-Framework Directive 2000/60/EC) and the need to share natural water resources is becoming highly important, especially to mitigate the effects of climate change. This process is reinforced by various international conventions which also have an impact on the current cross-border water agreements (Priváczki-Juhászné Hajdu, 2019).

A study was conducted in Romania to analyse data regarding the volume of goods transported on the IWWs and maritime transportation infrastructure. The considered timeframe for this paper is from 1990 to 2019 and the data was collected from sources such as annual reports of Governmental Agencies, Eurostat, and the National Institute of Statistics. Authors found that there was a severe lack of reported data or even data inconsistency between authorities. As economic policy implications we mention the need for investments in maintenance, development, and modernization of infrastructure to stimulate the positive trend in volumes of goods transported (Haiduc, Nicoara, & Neagu, 2022).

A location analysis model for Belgian intermodal terminals (LAMBIT) is developed and used to assess different policy measures in Belgium. The simulations show that the different policy measures oriented towards the rail/road and IWWs/road combinations should be incorporated in a coherent, integrated vision, in order to not create a modal shift between the different intermodal transport options. The methodology can easily be upscaled to a European level (Macharis & Pekin, 2009).

Findings on the Rhine and Danube IWT indicate that vessels' characteristics and operational features as well as the ports conditions are regionally different and are affected by various factors such as the locks' allowance, nautical status of waterways, economy of the region, etc. The recommendations for the promotion of IWT business in the Göta Älv-Lake Vänern are made in the domain of vessels' characteristics and operational features, the facility requirements, such as futures locks' dimensions, lifting gear for the container operation either on the vessels or ports, and the regulations' requirements for the ice and pilotage, etc (Bakhshian & Kachlami, 2019).

Based on multi-criteria analysis, one study tried to find a potential that can be developed as Alternative Transportation Logistics and determines the priority level of that potential Nur Pradana, Abdul Fattah, Rachmat Hidayat, Triyasa, & Yuliantini, 2020). Retrieval of data taken through a questionnaire distributed to experts in the field of logistics and related to the research being carried out. Based on primary data processing, it was found that Economics Aspects is a major potential to be developed and prioritized for consideration in making the IWWs as an Alternative Logistics Transport (Nur Pradana, Abdul Fattah, Rachmat Hidayat, Triyasa, & Yuliantini, 2020).

Information systems (existent systems, and technology for improvement)

Navigation and communication errors are the most frequent causes of accidents in IWW transport (Schweighofer, 2014). To ensure safe navigation, Automatic Identification Systems (AIS) have been used.

The River Information Services are categorized into many information levels (e.g., traffic information, logistics management information) which are connected to multiple users and levels of operation. In RIS systems, the personnel evaluates the data and decides which information should be dispatched to multiple users. **Human errors might occur, and the information received might not be the most appropriate as decisions are based on personal experience/judgement and similar business situations.** Therefore, the use of an automated system based on artificial intelligence may increase the efficiency of the entire system (James, Shenoy, Bhasi, & Nandakumar, 2019).

IWT is highly efficient in terms of greenhouse gas emissions but lacks economic competitiveness when compared to other modes of transport. Digital information services that foster the efficiency and sustainability of IWT are considered important elements for improving its attractiveness and reducing greenhouse gas emissions in the transportation sector. However, **IWT operators do not have sufficient insight into the extent of information on available services** (Specht, Bamler, Jović, & Meyer-Larsen, 2022). Having a single point of information provides several advantages: alleviate repetitive searching for information, saving time, easiness of updating and implementation of strategies against fraud, increasing user's trust; efficiency in complying with regulations and lower investments than maintaining many sources; simplified training of navigators, pilots and other employees, increased efficiency of the IWW transport, improving competitiveness (Andritsos, 2016).

Data from general or other specific meteorological networks are usually not representative of waterways' local weather - especially in case of shallow fog patches of river origin, or local low-level wind channels due to relief – because a very limited number of measurment stations are installed by riverbanks and/or not at affected places. Therefore, the weather forecasts do not consider the local conditions of the IWW. Based on the investigations of past incidents/accidents, it was found that weather can be a significant factor in casualties on IWWs (Sárközi, 2010). Additionally, climate change can intensify the extreme weather conditions and the number of accidents. Navigators usually do not have enough knowledge about the effects of climate change on navigation and the importance of their tasks to mitigate them and safeguard passengers and goods (Shahjahan & Chowdhury, 2018). Therefore, information systems are urged.

Since general meteorological networks cannot supply representative data and products customised to the skippers' needs, initiative solutions may come from other branches of state-owned transportation and industry by bilateral cooperation; and/or from the voluntary activity of marine partners themselves on a common interest base (Sárközi, 2010). Besides that, regular weather forecasts, navigational warnings, navigational aids, traffic monitoring equipment, and control tower facilities should be provided to port operations. Also, theoretical and practical trainings for navigators focused on learning the new technologies/systems and managing extreme weather conditions during navigation should be available (Shahjahan & Chowdhury, 2018).

Owing to the above, the improvement of information systems requires **investments as well into pilot systems and surveying measurements**, preferably by RIS providers from development funds, and by leading players of the waterway market (Sárközi, 2010). High relevance is shown for information by onboard as well as landside respondents that can be used for decisions related to voyage planning. This includes waterway-related information, such as bridge clearance heights or water levels and lock-related information as well as berth-related information. Location-related information types are of little demand and have lower importance ratings, which may reflect a weak interdependency with operational planning. Functionalities that address planning issues received strong support from the respondents, while the provision of real-time bridge clearance information as well as electronic port announcements have been stated as most important (Specht, Bamler, Jović, & Meyer-Larsen, 2022).

Key findings

Weather impacts and resilience

- Climate change may increase the frequency and intensity of extreme weather occurrences, which may result in an increase in transportation costs, suspension of operation, and damage to the infrastructure.
- The use of IWW transport allows the reduction of external costs when compared to other modes of transport. Therefore, it may help achieve the sustainable transport goal set by the European Union.

Logistics

- The future of IWW transport is entirely determined by two factors: integration into a multimodal water transport system, and climate change effects on navigation.
- The Danube was intensely used as a waterway until 1990 and after that its popularity decreased.
- There is a need for investments in the maintenance, development, and modernization of infrastructure to stimulate the positive trend in volumes of goods transported.

- Findings on the Rhine and Danube IWT indicate that vessels' characteristics and operational features as well as the port conditions are regionally different and are affected by various factors such as the locks' allowance, the nautical status of waterways, the economy of the region, etc.
- To protect Hungary against water damage, cross-border cooperation is extremely important which is based on the nearly 100-year-old water agreements with neighbouring countries.

Information systems

- Digital information services are important elements to foster economic competitiveness and sustainability of IWW transportation.
- In many cases, general or other specific meteorological networks are not representative for IWW users, therefore there is a need for innovative solutions to reduce uncertainty and fulfil IWW users' needs.
- Human errors may occur, however, the use of an automated system based on artificial intelligence may increase the efficiency of the entire operations.
- Location-related information types are of little demand and have lower importance ratings, while electronic port announcements have been stated as the most important information source.

3.3 Deep interviews

We summarized the main statements and **key findings** in the following structure:

- operational difficulties,
- other difficulties,
- impacts of weather,
- impacts of climate change,
- information system and service development (general remarks, available services, suggested services).

Operational difficulties

1. Investment in **basic technology related to shipping** (waterway infrastructure, vessels, etc.) is required to improve its productivity and competitiveness.
2. The **built infrastructure** of IWW (canals, flood gates, dams, dikes,...) **is fragile** because they have been established in some cases 200 years ago.
3. **The flexibility** of inland waterway transport **is low**; the existing capacity on the vessel cannot be transferred from one minute to the next.
4. Several clients prefer to transport goods by road or rail rather than by river because of the higher **availability and reliability**. Others have no willingness to shift from IWW to road/railway due to the increase in costs.
5. **Sediment formation** causes a problem in ports. Sediment is deposited in some sections/entrances of harbours and navigability is compromised and limited. The potential locations are known.

Other difficulties

1. **Studies** prepared in the IWW weather impact and climate change topics are **not coordinated**. The results are available from different sources.
2. The Danube's lack of **regulation** has a serious impact not only on shipping and port traffic but also on **groundwater level**s.
3. Due to heat waves, plants are growing in the rivers which compromises swimming and bathing, it’s quite dangerous to users.

Impacts of weather

1. Sudden **flash floods** have severe impacts, which cannot be reliably predicted**.**
2. **Low water levels** because of droughts make shipping impossible or operations inefficient.
3. **High-water level**s require more engine power and more careful mooring because of the higher water velocity. Space gauge has to be taken into account, for example when passing under bridges. High water level is rare these days.
4. **Floods** can not be mitigated, but the evacuation plan can be improved.
5. Sometimes the **wind** is strong which blocks navigation. High waves are generated which are dangerous. There are not so many windy periods (less than 20 days in a year in total), but above 40km/h, the pushing operation can be problematic. Strong wind may hinder the operation of a terminal; safe operation is permitted only up to a certain wind speed.
6. **Intensive rainfall** may endanger shipping as boats travel at their own risk.
7. In **heavy rain** and **cold weather**, the container may "freeze" in the boat. This will hinder loading. However, such causes are rare or have little effect.
8. **Icing** is not a relevant problem as it has occurred in recent years only in a few cases and for short periods.
9. **Storms** do not cause severe problems.
10. **Fog** is not a problem, with the right radar system navigation can be done properly.
11. The **port** (transhipment/loading processes) is affected by **lightning, gale-force winds, sleet (icing),** and **heavy snowfall with strong winds**. The duration of these extreme weather situations typically does not exceed 24 hours.

Impacts of climate change

1. Observations over the past 20 years show that climate change is causing **low water levels** to occur more frequently and for longer periods. The low water level is getting more and more unusual as well as unpredictable events such as in autumn and spring. Noticeably **drought** periods are increasing, too.
2. **High water levels** are becoming less frequent and less noticeable due to climate change.
3. However, the danger of **flash floods** requires more attention. Forecast of flash floods remain a challenge and better preparation becomes necessary. It’s expected that such events will be more and more often.
4. The probability of occurrence and duration of **icing** becomes smaller due to climate change.

Information system and service development

General remarks:

1. Money spent on information system development becomes money wasted, if the **river and the related infrastructure cannot be used** because of low water levels, etc.
2. **An integrated information system** is needed to enhance functional and spatial extension. The available information is spread (not integrated), so users do not know where to look for it or which information to trust.
3. **Improved cooperation** between administration, national agencies, shipping service providers, etc. is suggested to ensure the right conditions for navigation on waterways and in harbours.
4. Information services are not very relevant for tourism and recreational vessel traffic, it has importance in freight traffic.
5. Where the **traffic volume** is relatively **low**, the deployment of information systems is not cost-effective.
6. In "well-regulated" canals, the relevance of information systems is low.
7. **Several stochastic processes and multiplayer activities cannot be supported by information management**. Computerized information management support for the loading process is difficult, as the port is a meeting point for several actors with different aims and expectations (and with different ownership backgrounds).

Available services:

1. A few days' forecast gives relatively accurate information on **water level** and **weather**.
2. **The national meteorological institute** provides colour schemes for different weather conditions. In the case of severe weather conditions, they contact the affected areas (city council) and give more details and instructions.
3. **Water levels** are monitored and **recorded** by the meteorological institute manually on a national level every 6 hours. The values are precise and reliable. More frequent data collection is not possible due to the lack of human capacity.
4. Each terminal has a complex **terminal management system** connected to the customers. Usually, data is exchanged electronically.
5. The **Automatic Identification System** (AIS) contains information on vessels based on their GPS positions. From this, a lot of data can be retrieved. The vessels can be **followed in real-time**; however, in many cases, the **exact time of arrival** is difficult to estimate. It is therefore difficult to plan the work scheduling (loading). In most cases, vehicle tracking is worthless as the sole source of information. Additional information is also needed as countless actors influence transport.
6. The dispatcher (as an information hub) is responsible for communicating the time of arrival of the vessel to the appropriate parties.
7. The regional government (disaster protection agency) provides risk evaluation and an emergency line for contact (SMS communication). However, the emergency line is typically not available to get information about floods.

Suggested services:

1. Proper weather/meteorological forecasts support the elaboration of measures that can be taken to mitigate the effects of severe weather.
2. Appropriate water level forecast.
3. Installation of digital buoys indicating water levels.
4. Predicting an exact arrival time with high reliability in advance of several hours to plan terminal processes accurately.

5. Advanced port information services.
6. Interactive map where you can see all the variables, weather forecast, water level, sediment accumulation, etc.
7. Expanding access to Automatic Identification System (AIS), providing access to more actors (e.g., terminals) so that they can receive data through this system. This will enable ports to determine the arrival time of the vessel.
8. The schedule is to be optimized to avoid vessels to be stuck in the canals.
9. Modelling and predicting emergency, and what-if situations.
10. Cooperation and competition: comprehensive information about how IWW transport is efficient compared to other modes to mitigate modal shift. Information services should support all activities and decisions of stakeholders covering the entire supply chain and enhance competitiveness. Access rights should be determined, and secure information management is to be guaranteed, otherwise, some participants are not willing to share their data. A very clear understanding of who is going to use the system and how to use the system (not misuse, policies to be complied with) is needed. Free and paid information services – according to added value – may be introduced.

3.4 Questionnaire survey

The questionnaire survey was opened between 24/11/2022 and 03/01/2023. Altogether, 27 responses arrived. In this subsection, the most relevant results and consequences are drawn according to the four main pillars in the questionnaire (General information, Consequences of weather effects, Available information service and systems,and Needed information services).

3.4.1. General information about the respondents

According to the language, most responses were given in English and Hungarian (Figure 10).

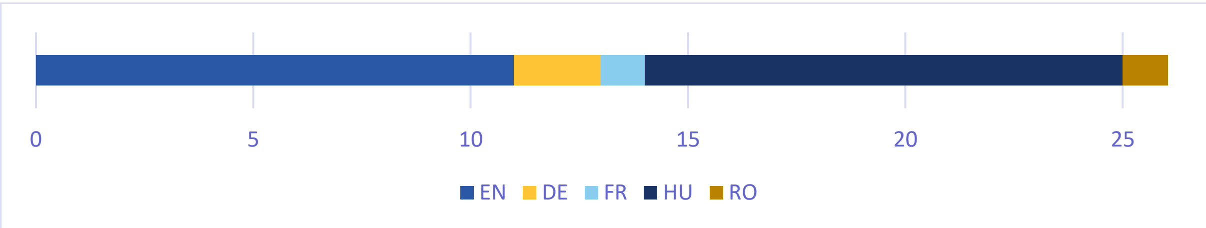

Figure 10: Responses according to the language

The respondents are mainly transport and logistic operators; a few infrastructure operators and a significant part of the respondents work in the connected sectors (Figure 11/a). One-third of the total respondents are representatives of carrying companies; thus, one-tenth of the respondents are vessel operators, loading companies or authority/governmental institutes (Figure 11/b).

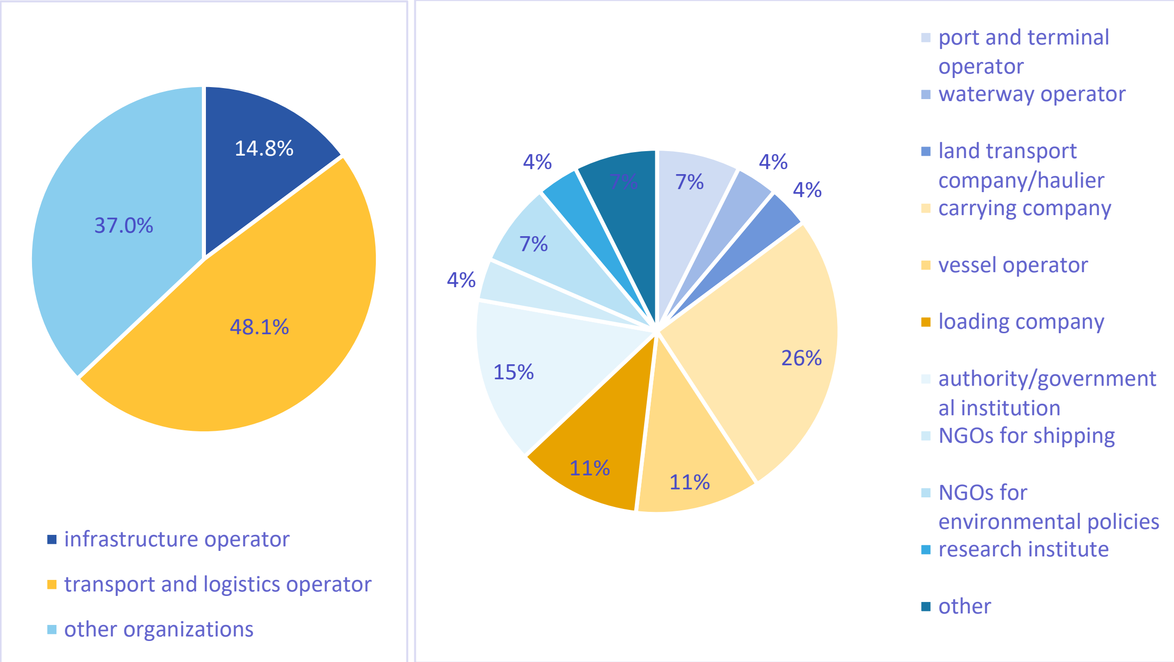

Figure 11: Respondent's main activity type (a) and activity specification (b)

The respondents' service area covers the European Union and the majority of the European Economic Area (Figure 12). Most of the respondents are operating in the case studies countries, such as Hungarian (21 respondents), Romania (15 respondents), and Belgium (11 respondents). But significant amount of respondents covers Germany as well (13 respondents).

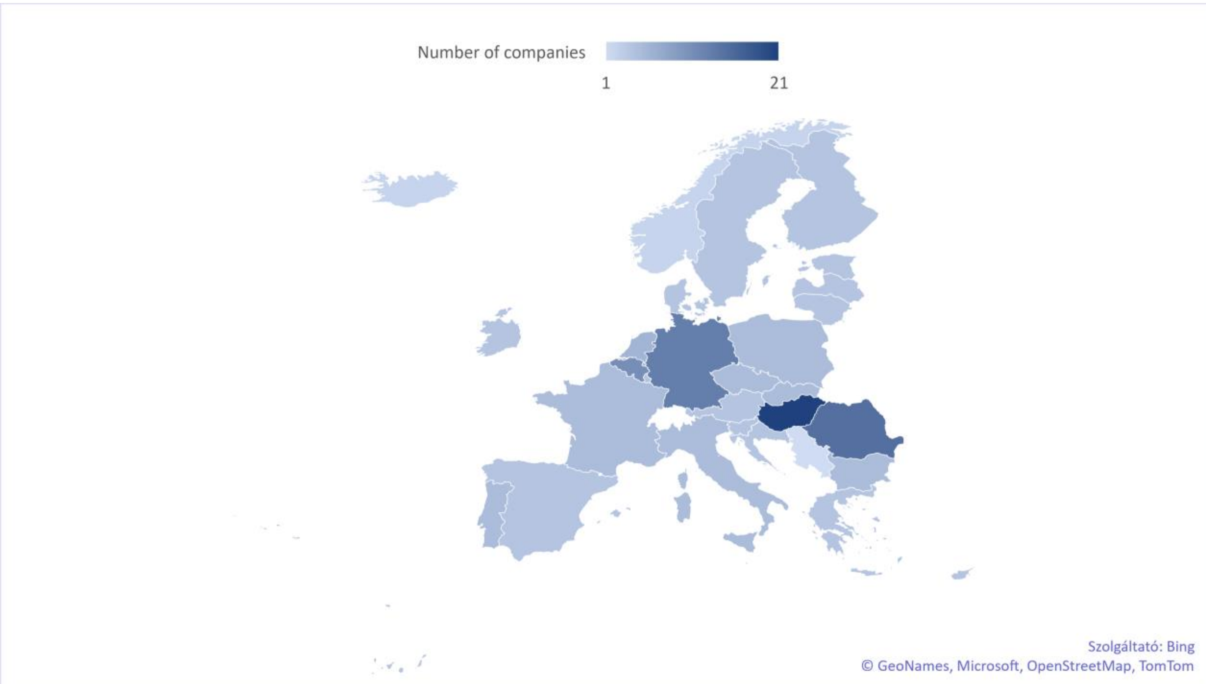

Figure 12: Respondents' service area

3.4.2. Experienced weather effects

The significance of experienced weather effects is depicted in Figure 13. Respondents evaluated the weather effects on a 0-5 scale. The highest aggregated significance is given to the low water level (3.4); thus, fog is the least relevant weather phenomenon (2.32). Icing, intense precipitation, and strong, stormy wind have similar medium significance (3.05-3.16). In addition, the significance of high-water level and heatwave to IWW is moderate (2.8).

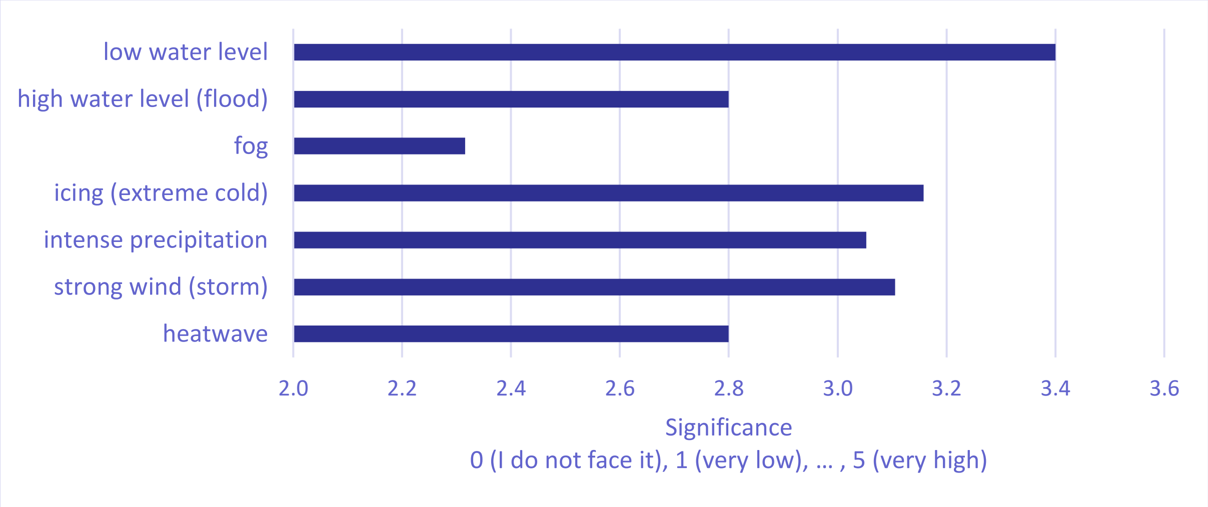

Figure 13: Significance of weather effects

The duration of a weather effect in a year can be retrieved from weather reports; however, an approximated duration can be gained from the respondents (Figure 14). The respondent chose discrete categories; the categories were converted into a number; thus, an aggregated duration value was determined. The longest-experienced weather effect is the low water level. The respondents meet this effect more than two months long annually, probably in the summer period. Significant duration is experienced in high-water level and heatwave (3 weeks). The other weather effects are experienced less then 2 weeks in a year.

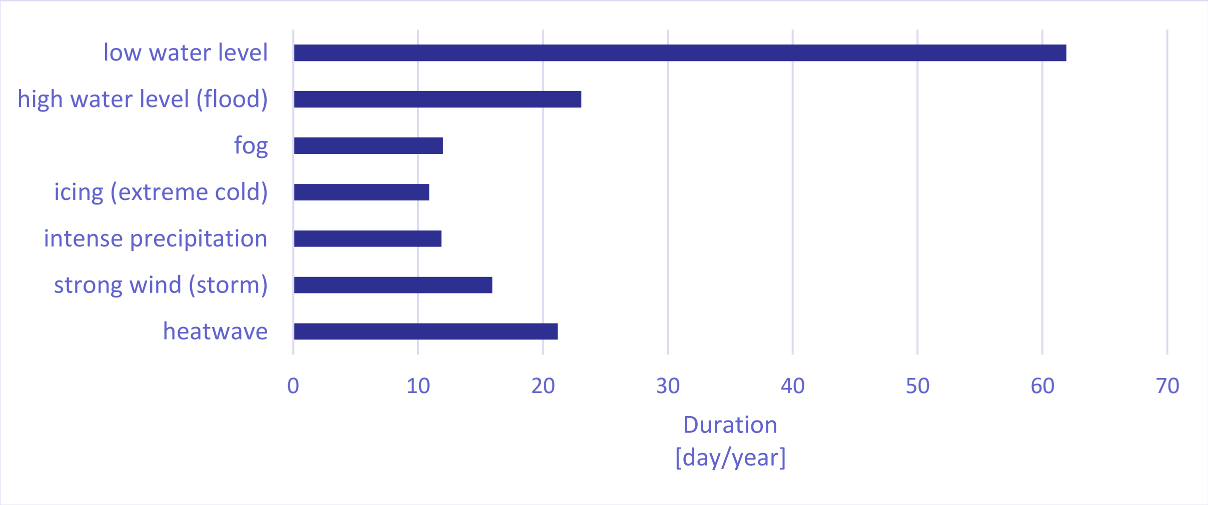

Figure 14: Experienced duration of a weather effects

As both the caused significance and duration of low water level are high, this weather effect may have serious drawbacks for IWWs; information and prediction of the low water may be relevant. Though the expected duration of icing, intense precipitation, and strong wind are low, their significance is high. Accordingly, information provision and prediction of these effects are also important.

3.4.3. Consequences of weather effects

The consequences of weather effects were investigated according to the impact areas. The respondents selected the weather effects that are responsible for a consequence according to impact areas. Between sets of consequences and weather effects a more-more relation type can be revealed. Namely, one consequence can be caused by several weather effects and one weather effect can cause several consequences.

Shipment

The consequences caused by such a weather effect during shipment are depicted in Figure 15. The different colours indicate the consequences. The low water level was found as the most influencing weather effect during shipment. All the other weather effects have less significant impact on consequence generation. The least influencing factor during shipment is the intense precipitation.

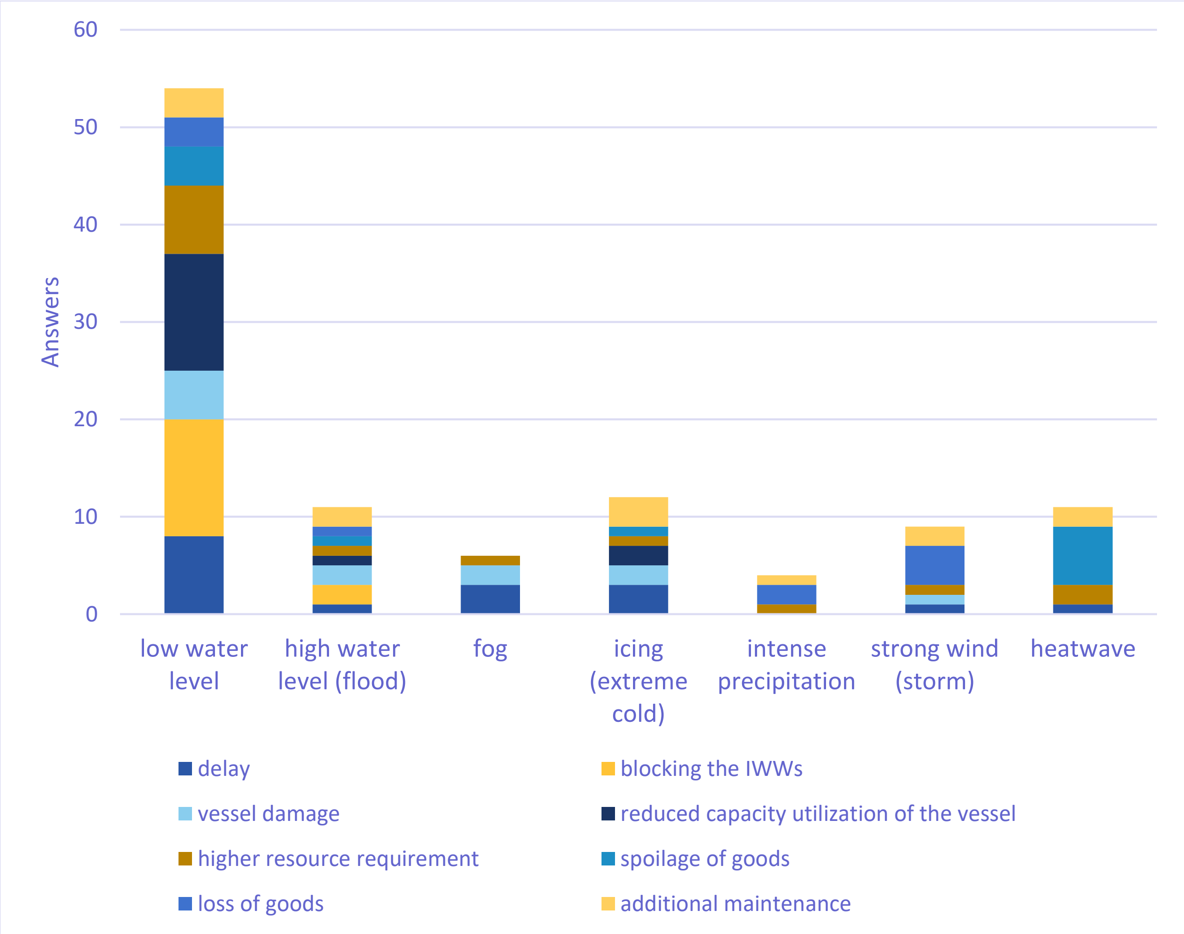

Figure 15: Consequences caused by a weather effect during shipment

Figure 16 summarises the rate of weather-generated consequences during shipment independently of the total number of consequences. Additional maintenance does not have any specific weather-related reason. However, the reduced capacity utilisation of vessels is caused mainly by the low water level. Furthermore, the low water level significantly causes delays, vessel damage, and higher resource requirement. The strong wind mainly causes loss of goods; thus, the spoilage of goods is caused by heatwaves. **As the periods of low water level are the longest in a year, these consequences may occur much more frequently than the others; thus, the shipment is highly influenced by low water level.**

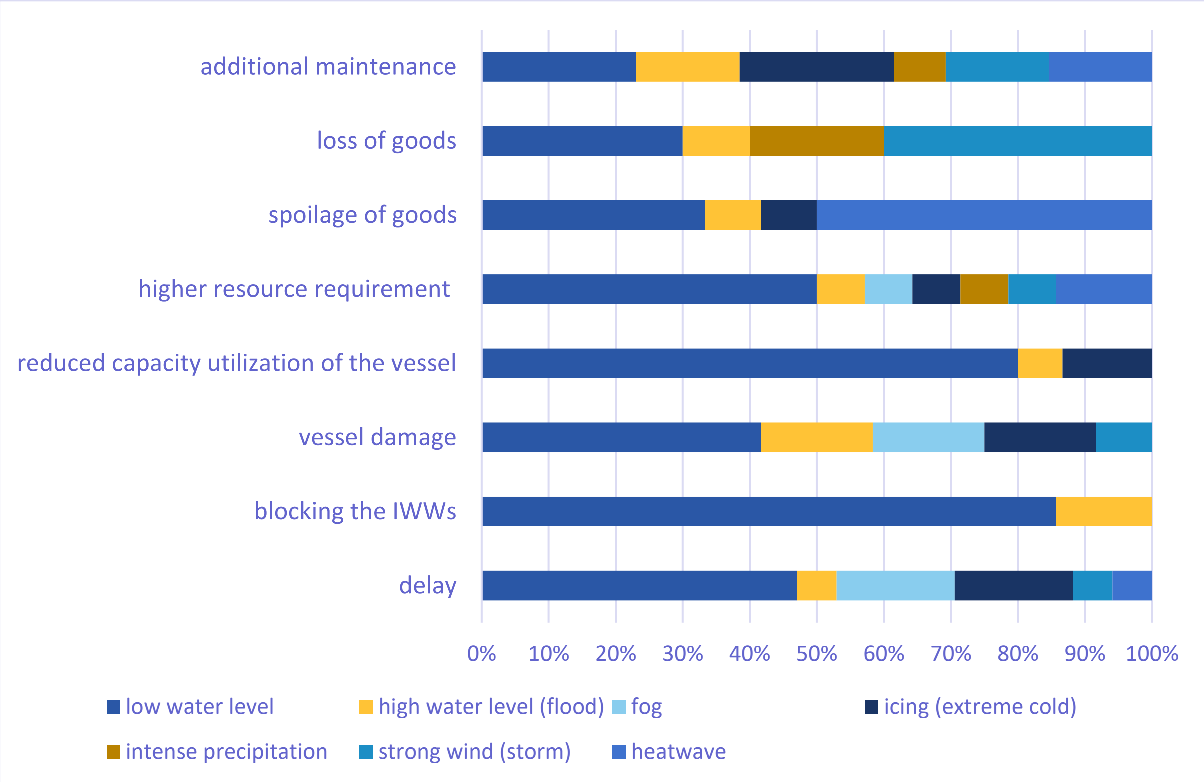

Figure 16: Rate of weather-generated consequences during shipment

Loading

The consequences caused by a weather effect during loading are depicted in Figure 17. The different colours indicate the consequences. Intense precipitation was found as the most influencing weather effect during loading. The strong wind also has a high influence; thus, heatwaves and high-water levels have a moderate influence. All the other weather effects have less significant impact on consequence generation. The least influencing factor during loading is the fog.

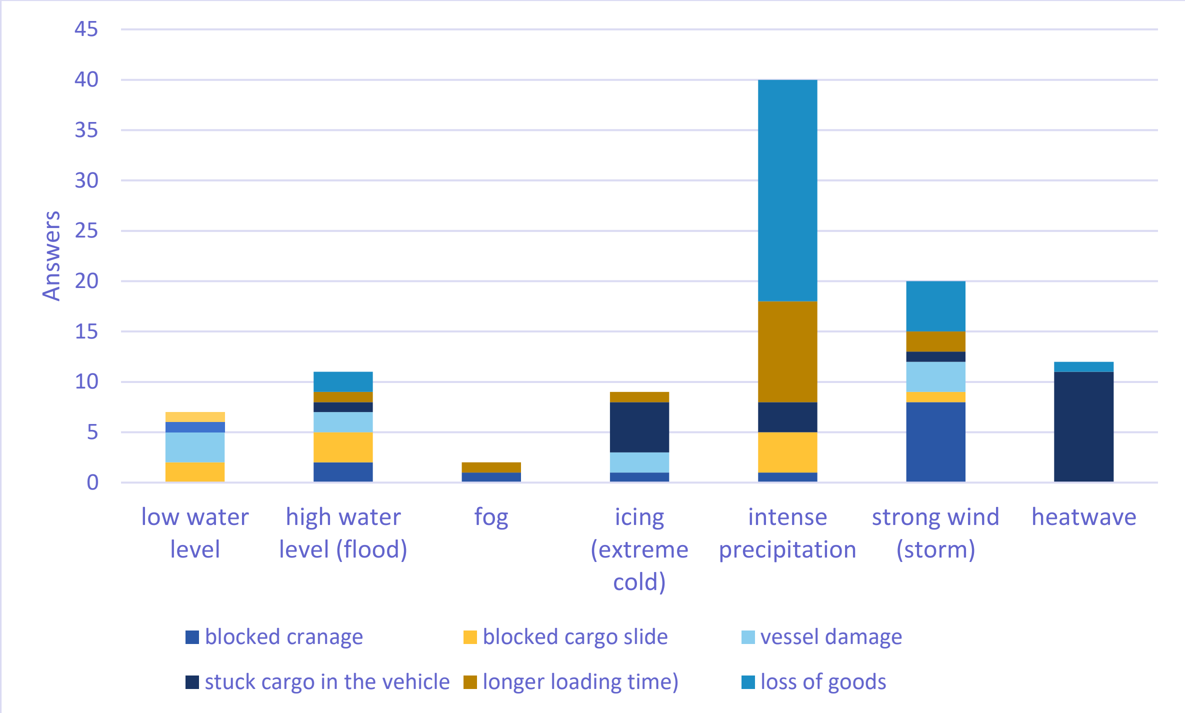

Figure 17: Consequences caused by a weather effect during loading

Figure 18 summarises the rate of weather-generated consequences during loading independently of the total number of consequences. The strong wind mainly causes blocked cranage. Low and high-water levels, icing, and strong wind almost equally cause vessel damage. Intense precipitation is the major cause of the loss of goods and longer loading time, but it also affects blocked cargo slide. Half of the stuck cargo in the vehicle is caused by heatwaves. **As the duration of intense precipitation in a year is not so long according to the respondents; the chance of consequences caused by this weather effect is low.**

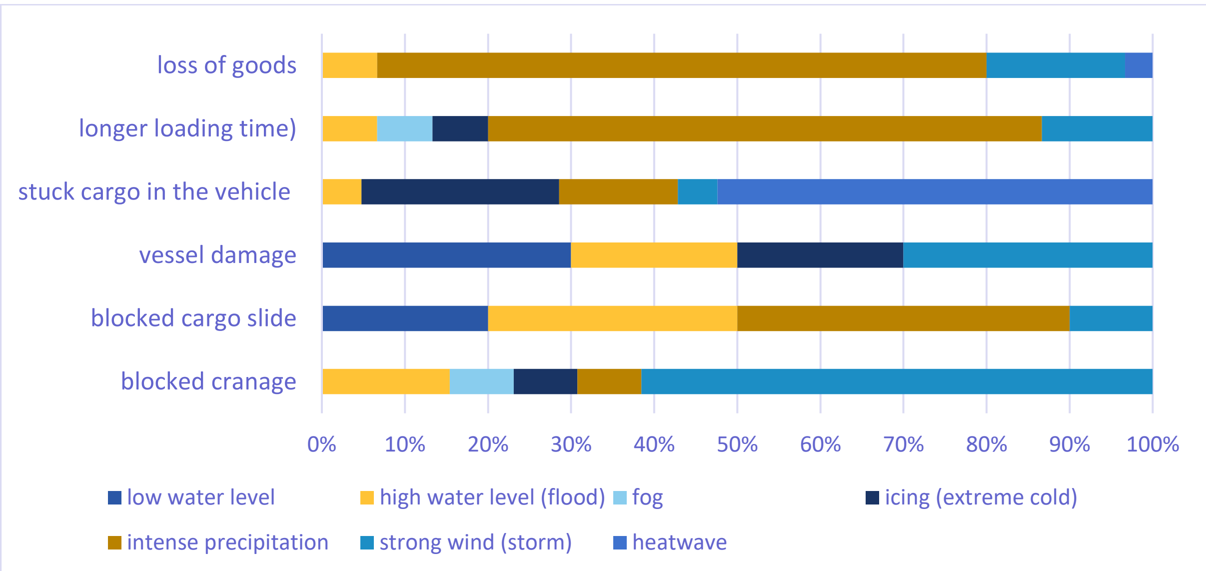

Figure 18: Rater of weather-generated consequences during loading

Storage

The consequences caused by a weather effect during storage are depicted in Figure 19. The different colours indicate the consequences. The high-water level was found to be the most influencing weather effect during storage. Furthermore, the low water level and icing also have high impacts. All the other weather effects have minimised impact on consequence generation.

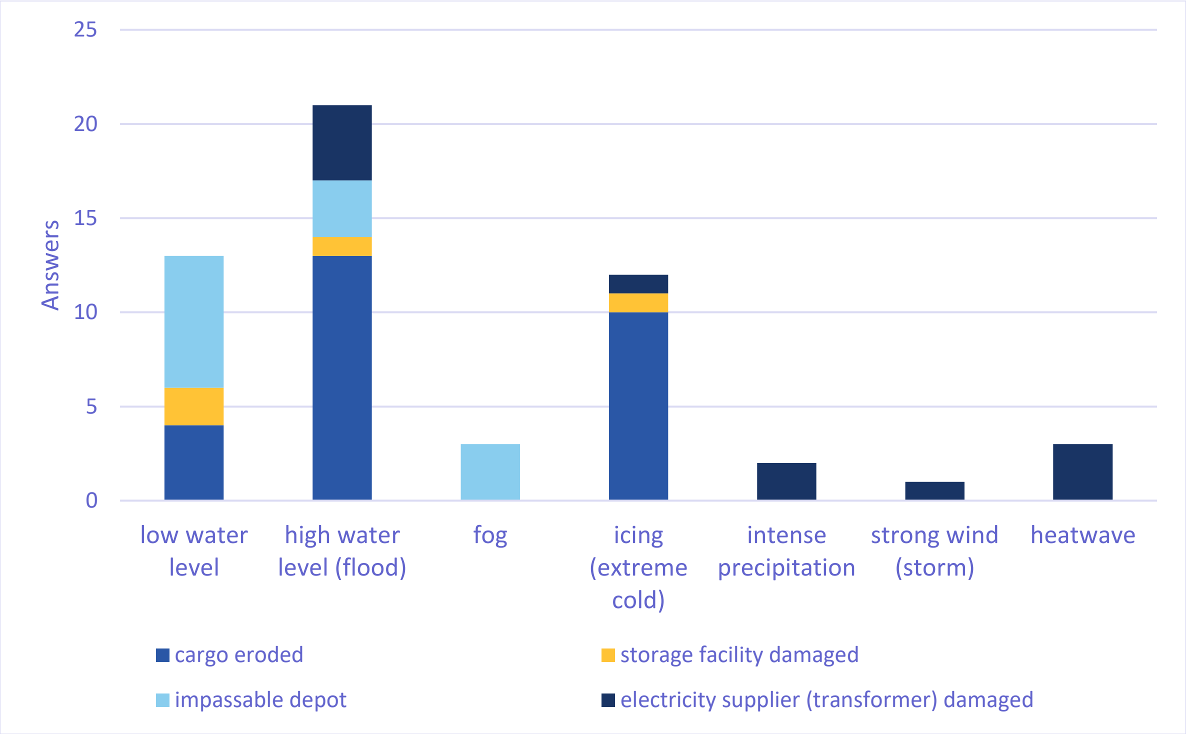

Figure 19: Consequences caused by a weather effect during storage

Figure 20 summarises the rate of weather-generated consequences during storage independently of the total number of consequences. According to the respondents, storage facility damage and impassable depots are mainly caused by low water level. The main weather-related cause of eroding cargo is the high-water level, but icing also has a considerable influence. High water level significantly influences all the consequences considered during storage.

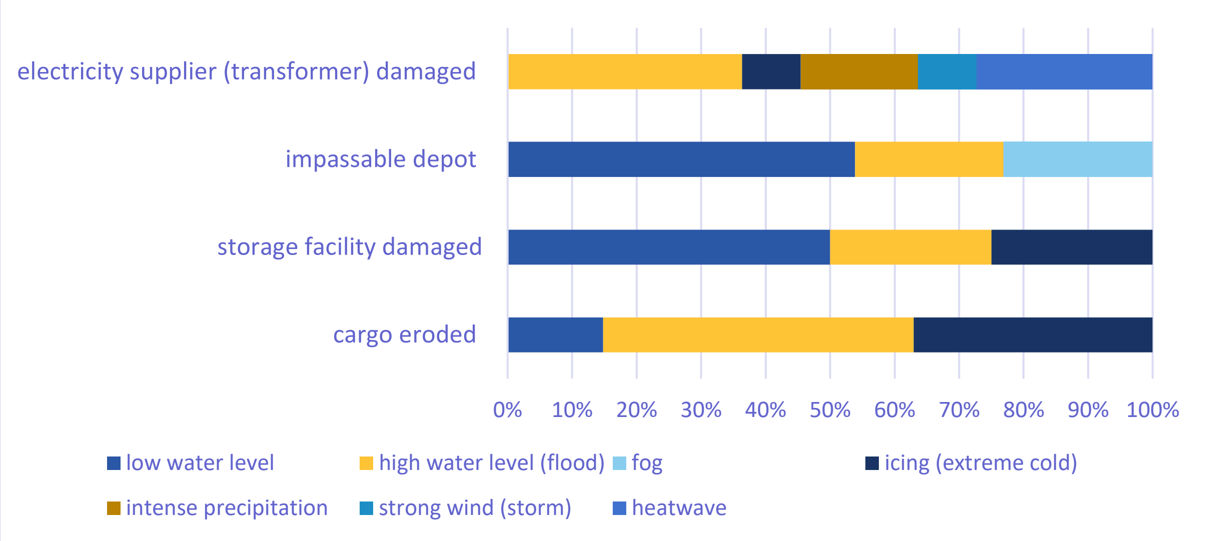

Figure 20: Rater of weather-generated consequences during storage

Weighted significance

The result of step 4 of the weighted significance calculation is summarised in Figure 21. Accordingly, the main findings are:

- Low water level is the most important, while precipitation is the least important weather effect during shipment.
- Precipitation is the most important, while the fog is the least important weather effect during loading.
- High-water level is the most important, while the strong wind is the least important weather effect during storage.

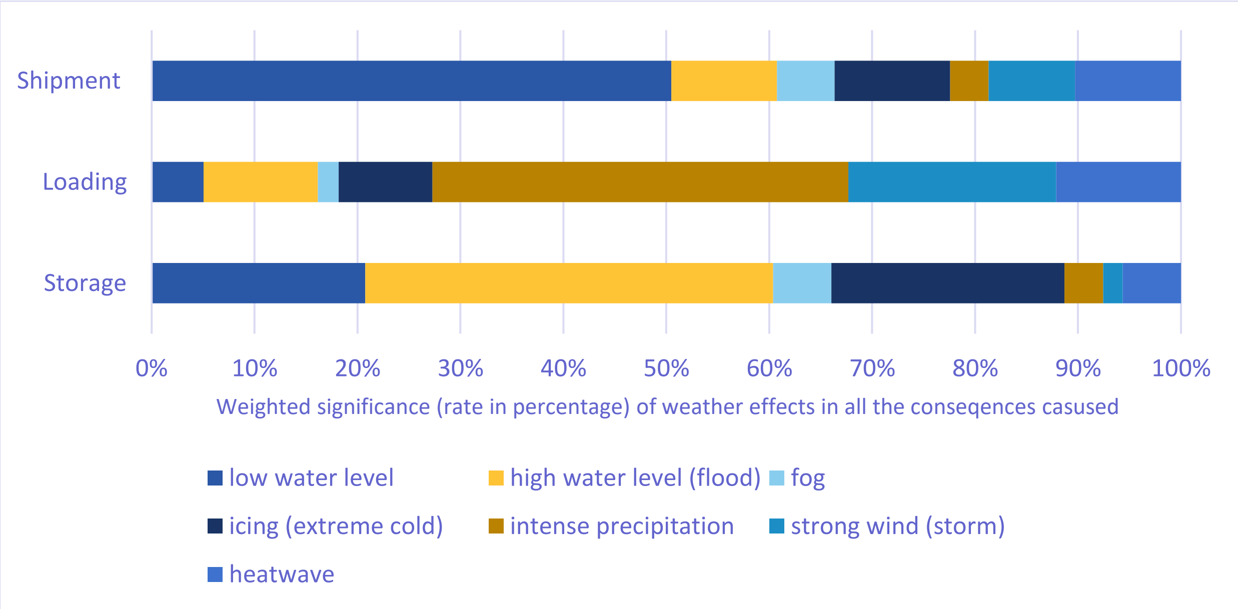

Figure 21: Weighted significance according to impact areas

The result of step 6, namely the weighted significance of weather effects considering all the consequences caused by weather effects during shipment, loading, and storage, as well as considering the rank of these impact areas is depicted in Figure 22. **It was found that the low water level is the most crucial factor in the whole IWW system, the high-water level comes in second place. This indicates the high impact of the water level. On the other hand, the fog and the heatwave were ranked in the last positions.**

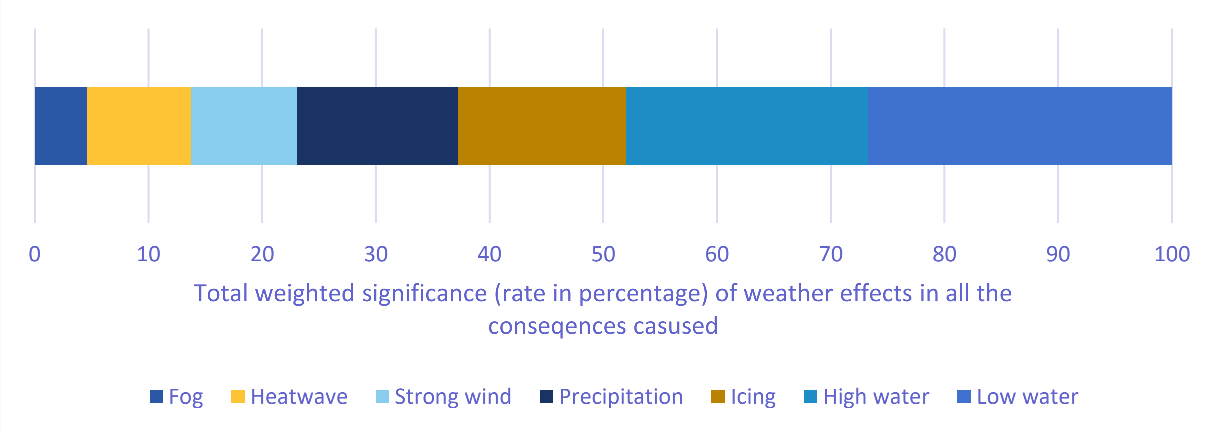

Figure 22: Total weighted significance

3.4.4. Available information systems and services

According to the respondents, the most used communication channel is an online application, but pure mobility phone-based communication is also popular (Figure 23). Radio-based communication is only used by vessel operators.

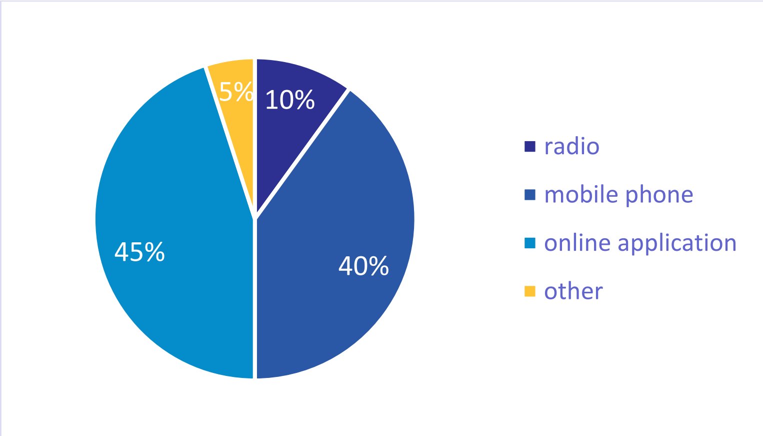

Figure 23: Primary communication channels used

The used information systems and services by the respondents:

- meteorological forecast: website of country-related weather forecast state agency (e.g., met.hu, meteoromania.ro) or private company (koponyeg.hu, foreca.hu, windy.com).
- water level information: website of national authorities (e.g., afdj.ro, hydroinfo.hu, elwis.de, doris.bmk.gv.at, vodniputovi.hr, hidmet.gov.rs, appd-bg.org, shmu.sk).

- water traffic information: website of national traffic authority (e.g., afdj.ro, roris.ro, vizugy.hu), special mobile application and website supported by the government (e.g., pannonris.hu). In addition, mobile phones and thus oral information gathering was indicated by several respondents.
- port information: Several respondents stated that there is no port-related information source, and mobile phones should be used to contact directly to the port. Hungarian respondents highlighted the recently launched KIR application (port information system in Hungary) as a good example.

Evaluation of used info communication service types

The respondents evaluated the used info communication service types on a 1-5 scale according to the accuracy of the information provided. The result is summarised in Figure 24. The respondents are the most satisfied with the water level information. High satisfaction is proved for the GPS-based navigation, internet availability and meteorological forecast. The lowest satisfaction can be observed for the water traffic and port information.

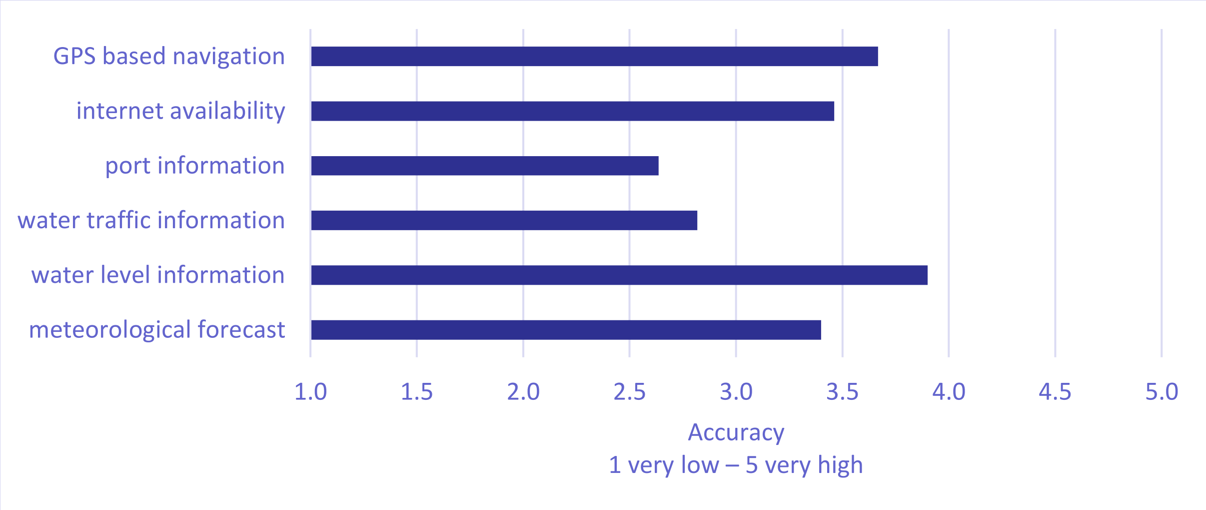

Figure 24: Evaluation of used info communication service types

3.4.5. Needed/proposed information services

Decision making and operational control tasks need novel information services.

For *strategic planning,* several respondents highlighted that a service that can integrate multiple data sources in a holistic approach is needed. A notable portal was mentioned (danubeportal.com), which can be a good basis for an integrated service, but the accuracy and variety of the information provided should be higher. Other respondents committed to the need for establishing obligatory sail plans for all transits in conjunction with waterway traffic control services. A loading company expresses its attitude towards properly estimated traffic data. However, a Hungarian carrying company stated that all the necessary information is available; there is no need for information service developments. Forecasting weather effects and maintenance events were noted as an important service for *tactical planning* and *operational control and planning*.

Importance of information services

The importance of given information services was evaluated by the respondents on a 0-5 scale. The result is summarised in Figure 25. According to the respondents, the most important information services would be automatic, location-based weather information, information about short-term bottlenecks, and automatic, location-based traffic-related information. These results correlate with the result of the quality evaluation. Moderately important functions are the signal visualisation during navigation, the information about the predicted available capacity of pots and border stations and the information collection and recording by users along waterways. In addition, far the least important function is the hourly notification about the water level. The possible reason for this fact is that respondents were satisfied with the existing water level information service.

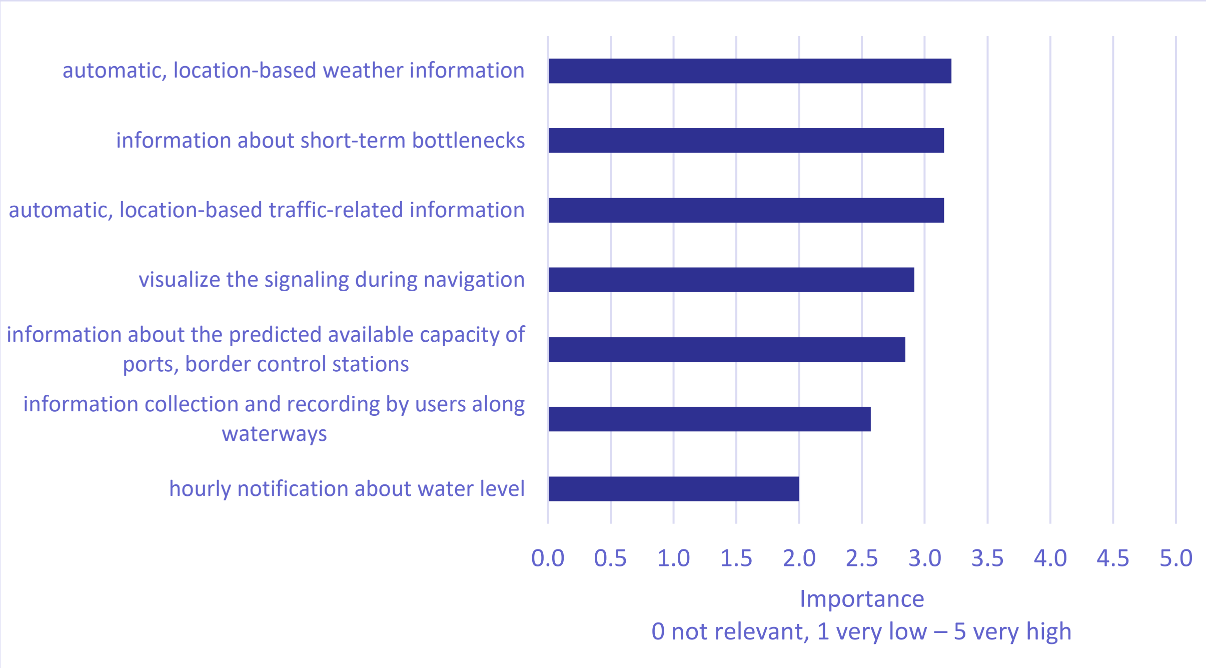

Figure 25: Importance of information services

Forecast requirement of weather effects

To provide novel information services, the expectation towards the forecast duration in advance of weather effects were revealed. According to the respondents, the low water level and icing should be forecasted more than one week earlier. In addition, high-water levels and heatwaves should be forecasted five days before. Two days forecast in advance is enough for strong wind, intense precipitation and fog. The forecast needed in days in advance according to weather effects is presented in Figure 26.

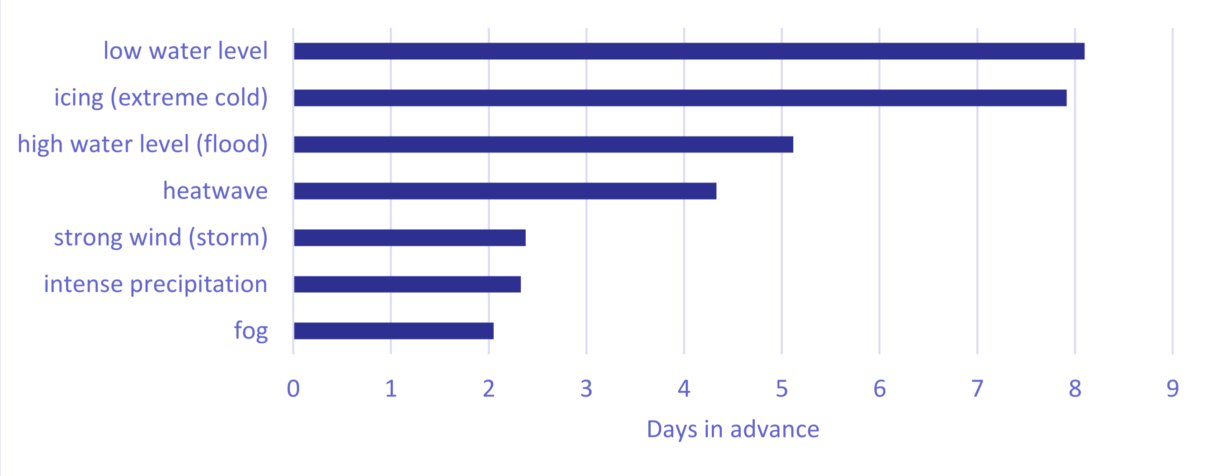

Figure 26: Forecast needed in days in advance

Communication deficiencies

Communication deficiencies were noted regarding route monitoring of the vessels by a loading company and the warnings of breaches by a waterway operator. A Hungarian loading company expresses the lack of connection opportunities to the Automatic Identification System (AIS).

Troubleshooting/emergency plans

Several respondents have already prepared and applied troubleshooting and emergency plans. For instance:

- a vessel operator for a storm, low water problems without notice, heatwaves
- a carry and loading company for loading and unloading
- a waterway operator for flooding, breaches, and damage to waterway dikes, embankments and walls, bridges, aqueducts and viaducts

3.4.6. Summary

The most relevant key findings of the questionnaire survey are as follows:

- Water levels are the most relevant weather issue in the IWW-sector
  - Shipment is influenced highly by low water levels
  - Loading is influenced strongly by intense precipitation
  - Storage is influenced mostly by high-water levels
- Low water levels and icing should be forecasted more than one week in advance
- Water level information is accurate already; additional hourly notification about water level is not important
- Port-related and traffic information is lacking; related information services are important

4 PLOTO end-users' requirements

In the following paragraphs, the end-users' requirements (per requirement type), as identified and prioritised by the end-users and partners, are presented.

4.1 PLOTO Functional Requirements

The functional requirements of the PLOTO platform are displayed below (Table 3).

Table 3: PLOTO fuctional requirements

FR-1			
Version No	1.0	**Priority**	Must-have
Requirement Category	Wind	**Relative WP**	WP2
Requirement Name	Weather situation	**Relative Module**	TBD
Requirement Description	Providing current wind data (15 mins).	**Relative Use Case/Scenario**	Use Cases A, B
FR-2			
Version No	1.0	**Priority**	Must-have
Requirement Category	Water level	**Relative WP**	WP2
Requirement Name	Weather situation	**Relative Module**	TBD
Requirement Description	Providing current water level (twice per day).	**Relative Use Case/Scenario**	Use Cases A, B, C
FR-3			
Version No	1.0	**Priority**	Must-have
Requirement Category	Fog	**Relative WP**	WP2
Requirement Name	Weather situation	**Relative Module**	TBD
Requirement Description	Providing current fog situation (15 mins).	**Relative Use Case/Scenario**	Use Cases A, B
FR-4			
Version No	1.0	**Priority**	Should-have
Requirement Category	Precipitation	**Relative WP**	WP2
Requirement Name	Weather situation	**Relative Module**	TBD
Requirement Description	Providing current precipitation data (once per hour).	**Relative Use Case/Scenario**	Use Case C
FR-5			
Version No	1.0	**Priority**	Must-have
Requirement Category	Precipitation	**Relative WP**	WP2
Requirement Name	Weather situation	**Relative Module**	TBD
Requirement Description	Providing current precipitation data (15 mins).	**Relative Use Case/Scenarioz`**	Use Cases A, B
FR-6			
Version No	1.0	**Priority**	Must-have
Requirement Category	Temperature	**Relative WP**	WP2
Requirement Name	Weather situation	**Relative Module**	TBD

Requirement Description	Providing current air temperature data (15 mins).	**Relative Use Case/Scenario**	Use Cases A, B
FR-7			
Version No	1.0	**Priority**	Should-have
Requirement Category	Traffic	**Relative WP**	WP2
Requirement Name	Traffic situation	**Relative Module**	TBD
Requirement Description	Providing vessel position data (TBD).	**Relative Use Case/Scenario**	Use Cases A, B
FR-8			
Version No	1.0	**Priority**	Should-have
Requirement Category	Shipment	**Relative WP**	WP2
Requirement Name	Traffic situation	**Relative Module**	TBD
Requirement Description	Providing characteristics of the vessel and cargo (event-based).	**Relative Use Case/Scenario**	Use Cases A, B
FR-9			
Version No	1.0	**Priority**	Must-have
Requirement Category	Wind forecast	**Relative WP**	WP2
Requirement Name	Wind	**Relative Module**	TBD
Requirement Description	Direction and strength of wind must be known in advance on certain locations for a predefined time interval and updated with predefined frequency. (update: hourly, resolution: 15 minutes).	**Relative Use Case/Scenario**	Use Case B
FR-10			
Version No	1.0	**Priority**	Must-have
Requirement Category	Water level forecast	**Relative WP**	WP2
Requirement Name	Water-level	**Relative Module**	TBD
Requirement Description	Water level must be known in advance on certain locations, in a predefined time interval, and updated with predefined frequency. (update: once per day, resolution: 24 hrs).	**Relative Use Case/Scenario**	Use Cases A,B
FR-11			
Version No	1.0	**Priority**	Could-have
Requirement Category	Predicting arrival time	**Relative WP**	WP2
Requirement Name	Arrival time	**Relative Module**	TBD
Requirement Description	Knowing the parameters (vessel parameters, cargo parameters, departure location and time, arrival location) of a navigation task, the arrival time could be predicted with a high reliability. (update: hourly; resolution: minute).	**Relative Use Case/Scenario**	Use Case B
FR-12			
Version No	1.0	**Priority**	Must-have

Requirement Category	Modelling water level and flood arrival time in fairway and floodplain for specified dike breaching scenario.	**Relative WP**	WP2
Requirement Name	IWW section and floodplain flooding	**Relative Module**	TBD
Requirement Description	Location, water level, time and duration of flood must be modelled for various pre-defined scenarios.	**Relative Use Case/Scenario**	Use Case C
FR-13			
Version No	1.0	**Priority**	Should-have
Requirement Category	Fog forecast	**Relative WP**	WP2
Requirement Name	Fog	**Relative Module**	TBD
Requirement Description	Location, duration, density, visibility-range should be known in advance near port and other physical infrastructure. (update: 15 minutes, resolution: 15 minutes).	**Relative Use Case/Scenario**	Use Cases A, B
FR-14			
Version No	1.0	**Priority**	Should-have
Requirement Category	Precipitation forecast	**Relative WP**	WP2
Requirement Name	Precipitation	**Relative Module**	TBD
Requirement Description	Type and volume of precipitation should be known in advance on certain locations for a predefined time interval and updated with predefined frequency. (update: hourly, resolution: 15 minutes).	**Relative Use Case/Scenario**	Use Cases A,B
FR-15			
Version No	1.0	**Priority**	Should-have
Requirement Category	Temperature forecast	**Relative WP**	WP2
Requirement Name	Temperature	**Relative Module**	TBD
Requirement Description	Temperature should be known in advance on certain locations for a predefined time interval and updated with predefined frequency. (update: hourly, resolution: one hour).	**Relative Use Case/Scenario**	Use Cases A,B
FR-16			
Version No	1.0	**Priority**	Must-have
Requirement Category	Users authorisation	**Relative WP**	WP6
Requirement Name	Users authorisation	**Relative Module**	TBD
Requirement Description	Only authorised users must access the system. Unauthorized access must be declined.	**Relative Use Case/Scenario**	Use Cases A, B, C
FR-17			
Version No	1.0	**Priority**	Must-have

Requirement Category	Notification	**Relative WP**	WP6
Requirement Name	Notification	**Relative Module**	TBD
Requirement Description	Notification based on the user's current locations (e.g. weather, traffic).	**Relative Use Case/Scenario**	Use Cases A, B, C
FR-18			
Version No	1.0	**Priority**	Must-have
Requirement Category	Map classification	**Relative WP**	WP6
Requirement Name	Map classification	**Relative Module**	TBD
Requirement Description	Diverse strategies must be followed for different Tiers.	**Relative Use Case/Scenario**	Use Cases A,B
FR-19			
Version No	1.0	**Priority**	Must-have
Requirement Category	Threats monitoring	**Relative WP**	WP4
Requirement Name	Threats monitoring	**Relative Module**	TBD
Requirement Description	PLOTO system should monitor specific threats (e.g. flood, draught, storm).	**Relative Use Case/Scenario**	Use Cases A,B
FR-20			
Version No	1.0	**Priority**	Must-have
Requirement Category	User Management	**Relative WP**	WP6
Requirement Name	User Management	**Relative Module**	TBD
Requirement Description	Administrators must be able to manage users accounts.	**Relative Use Case/Scenario**	Use Cases A, B, C
FR-21			
Version No	1.0	**Priority**	Must-have
Requirement Category	Users Roles Management	**Relative WP**	WP6
Requirement Name	Users Roles Management	**Relative Module**	TBD
Requirement Description	All users must have access to the role they are matched with.	**Relative Use Case/Scenario**	Use Cases A, B, C
FR-22			
Version No	1.0	**Priority**	Must-have
Requirement Category	Damage maps	**Relative WP**	WP6
Requirement Name	Damage maps	**Relative Module**	TBD
Requirement Description	PLOTO system must provide fast assessment damage maps (satellite, ground sensor and UAV-based).	**Relative Use Case/Scenario**	Use Cases A, B, C
FR-23			
Version No	1.0	**Priority**	Must-have
Requirement Category	User Interface	**Relative WP**	WP6
Requirement Name	User Interface	**Relative Module**	COP
Requirement Description	COP will be generated by assimilating data from all PLOTO information (climate data and services, fused and raw data from all kind of sensors (ground, space	**Relative Use Case/Scenario**	Use Cases A, B, C

	and UAVs), simulation results, vulnerability information as well as all IWW elements and metadata in terms of GIS information layers and depicted in an advanced 3D visualization environment.		
FR-24			
Version No	1.0	**Priority**	Must-have
Requirement Category	User Interface	**Relative WP**	WP6
Requirement Name	User Interface	**Relative Module**	COP; DSS
Requirement Description	COP must provide a common operational picture, enhance the situational awareness and support desicion-making of operators.	**Relative Use Case/Scenario**	Use Cases A,B
FR-25			
Version No	1.0	**Priority**	Must-have
Requirement Category	User Interface	**Relative WP**	WP6
Requirement Name	User Interface	**Relative Module**	IWAT
Requirement Description	PLOTO system must demonstrate IWW operators' seamless operations during both maintenance and responding to crisis situations.	**Relative Use Case/Scenario**	Use Cases A,B
FR-26			
Version No	1.0	**Priority**	Must-have
Requirement Category	User Interface	**Relative WP**	WP6
Requirement Name	User Interface	**Relative Module**	IMS
Requirement Description	PLOTO system must demonstrate the standard response procedures for every hazard and incident type will be integrated in the IMS as workflow of proposed actions or proposed resources to be used, enabling operators to take the proper decisions in due time.	**Relative Use Case/Scenario**	Use Cases A,B
FR-27			
Version No	1.0	**Priority**	Must have
Requirement Category	GNS (Good Navigation Status)	**Relative WP**	WP2
Requirement Name	Draught	**Relative Module**	TBD
Requirement Description	Draught is a "hard" indicator (related to the physical waterway infrastructure) of GNS (good navigation status) stated by TEN-T regulation for IWW. As regards "draught" for the minimum requirement in the TEN-T Guidelines (2.5 metres as mentioned above), this is seen as a value of least 2.5 metre of	**Relative Use Case/Scenario**	Use case A

	possible draught of the vessel while still being able to safely navigate on the section of the TEN-T Network. Regarding free-flowing river sections, target values are related to reference water levels in these sections, in order to reflect the natural and statistical variations in water discharge. The reference high and lower water levels (MHW and MLW),relative to the determined reference water levels, are of particular importance for the design of the waterway, which refer to the water levels at which the full functionality of the waterway is available to for inland navigation. The reference water levels, both high and low, are set by the water management authority (eg AFDJ) and laid down in its management plan.		

4.2 PLOTO Non-Functional Requirements

In the table below (Table 4), the non-functional requirements of the PLOTO platform are presented.

Table 4: PLOTO non-fuctional requirements

NFR-1			
Version No	1.0	**Priority**	Must-have
Requirement Category	Security	**Relative WP**	WP6
Requirement Name	Secure communication	**Relative Module**	TBD
Requirement Description	The system should ensure secure communication, data transactions and data storage.	**Relative Use Case/Scenario**	Use Cases A, B, C
NFR-2			
Version No	1.0	**Priority**	Could-have
Requirement Category	Privacy	**Relative WP**	WP6
Requirement Name	Pseudonymisation mechanism	**Relative Module**	TBD
Requirement Description	The system should apply proper pseudonymisation mechanisms to ensure data protection and privacy.	**Relative Use Case/Scenario**	Use Cases A, B, C
NFR-3			
Version No	1.0	**Priority**	Should-have
Requirement Category	Data storage	**Relative WP**	WP6
Requirement Name	Data storage	**Relative Module**	Middleware

Requirement Description	The system should store all data-metadata needed.	Relative Use Case/Scenario	Use Cases A, B, C
NFR-4			
Version No	1.0	Priority	Must-have
Requirement Category	Weather Stations data	Relative WP	WP4
Requirement Name	Weather Stations data	Relative Module	
Requirement Description	Weather Stations data must be in a commonly accepted format.	Relative Use Case/Scenario	Use Cases A,B
NFR-5			
Version No	1.0	Priority	Must-have
Requirement Category	Models' output	Relative WP	WP4
Requirement Name	Models' format	Relative Module	TBD
Requirement Description	Models' output format should be in a commonly accepted format and resolution (e.g., shapefile, geoTiff, csv)	Relative Use Case/Scenario	Use Cases A, B, C

4.3 PLOTO Interface Requirements

The interface requirements of the PLOTO platform are displayed below (Table 5).

Table 5: PLOTO interface requirements

IR-1			
Version No	1.0	Priority	Must-have
Requirement Category	Display and map hazard modelling outcomes.	Relative WP	WP4
Requirement Name	Map	Relative Module	COP
Requirement Description	User should receive simulation results, hazard (e.g., inundation extent and depth) and vulnerability information as well as IWW elements.	Relative Use Case/Scenario	Use Case C
IR-2			
Version No	1.0	Priority	Should-have
Requirement Category	Several related information services are available on one user interface.	Relative WP	WP6
Requirement Name	Common interface	Relative Module	COP
Requirement Description	Users should receive a comprehensive 'picture' about all circumstances, which may influence their operational decisions, in an easy accessible and understandable way.	Relative Use Case/Scenario	Use Cases A,B
IR-3			
Version No	1.0	Priority	Could-have
Requirement Category	Interactive map with all relevant information.	Relative WP	WP2

Requirement Name	Map	**Relative Module**	COP
Requirement Description	Users should receive a comprehensive 'picture' with location data and visualization about all circumstances, which may influence their operational decisions, in an easy accessible and understandable way especially providing location-based information services with alerts and notifications. Different information types may be visualized on different layers of the map. E.g., wind layer, temperature layer, water level layer.	**Relative Use Case/Scenario**	Use Cases A,B
IR-4			
Version No	1.0	**Priority**	Could-have
Requirement Category	Interactive table	**Relative WP**	WP2
Requirement Name	Table	**Relative Module**	TBD
Requirement Description	List of the location-based IWW-related events in the frame of the route plan. Based on the route plan, users see the forecasted conditions of IWW sections at their expected arrival time. E.g., what is 50 km ahead the conditions 3-hour later.	**Relative Use Case/Scenario**	Use Case B
IR-5			
Version No	1.0	**Priority**	Must-have
Requirement Category	User Interface	**Relative WP**	WP6
Requirement Name	User Interface	**Relative Module**	COP
Requirement Description	The user interface design shall make the user's interaction with the system as simple and efficient as possible, in terms of accomplishing their goals.	**Relative Use Case/Scenario**	Use Cases A, B, C
IR-6			
Version No	1.0	**Priority**	Must-have
Requirement Category	User Interface	**Relative WP**	WP6
Requirement Name	User Interface	**Relative Module**	DT
Requirement Description	Data must be represented in high resolution for critical, important and high impact (based on the end-users needs and input) assets, buildings and structures that will be represented in the DT.	**Relative Use Case/Scenario**	Use Cases A,B
IR-7			
Version No	1.0	**Priority**	Must have

Requirement Category	Predictions about the water levels	**Relative WP**	TBD
Requirement Name	Estimated draught	**Relative Module**	TBD
Requirement Description	Predictions about the impact of climate change (changing water levels) shall be taken into account in the GNS process as they may lead to new possibilities to improve navigation on waterways and the waterway management.	**Relative Use Case/Scenario**	Use case A

4.4 PLOTO Usability Requirements

In the table below (Table 6), the usability requirements of the PLOTO platform are presented.

Table 6: PLOTO usability requirements

UR-1			
Version No	1.0	**Priority**	Should-have
Requirement Category	Efficiency	**Relative WP**	All Technical WPs
Requirement Name	Efficiency	**Relative Module**	All PLOTO modules
Requirement Description	Tasks shall be easily accomplished.	**Relative Use Case/Scenario**	Use Cases A, B, C
UR-2			
Version No	1.0	**Priority**	Should-have
Requirement Category	Efficiency	**Relative WP**	All Technical WPs
Requirement Name	Efficiency	**Relative Module**	All PLOTO modules
Requirement Description	Tasks shall be accomplished quickly.	**Relative Use Case/Scenario**	Use Cases A, B, C
UR-3			
Version No	1.0	**Priority**	Should-have
Requirement Category	Efficiency	**Relative WP**	All Technical WPs
Requirement Name	Efficiency	**Relative Module**	All PLOTO modules
Requirement Description	Tasks shall be accomplished with few or no user errors.	**Relative Use Case/Scenario**	Use Cases A, B, C
UR-4			
Version No	1.0	**Priority**	Should-have
Requirement Category	Efficiency	**Relative WP**	All Technical WPs
Requirement Name	Efficiency	**Relative Module**	All PLOTO modules
Requirement Description	The user shall be able to achieve expected goals.	**Relative Use Case/Scenario**	Use Cases A, B, C
UR-5			
Version No	1.0	**Priority**	Should-have
Requirement Category	Effectiveness	**Relative WP**	All Technical WPs
Requirement Name	Effectiveness	**Relative Module**	All PLOTO modules
Requirement Description	The System shall be useful.	**Relative Use Case/Scenario**	Use Cases A, B, C

UR-6			
Version No	1.0	Priority	Should-have
Requirement Category	Effectiveness	Relative WP	All Technical WPs
Requirement Name	Effectiveness	Relative Module	All PLOTO modules
Requirement Description	The System shall be reliable.	Relative Use Case/Scenario	Use Cases A, B, C
UR-7			
Version No	1.0	Priority	Should-have
Requirement Category	Effectiveness	Relative WP	All Technical WPs
Requirement Name	Effectiveness	Relative Module	All PLOTO modules
Requirement Description	The System shall work accurately.	Relative Use Case/Scenario	Use Cases A, B, C
UR-8			
Version No	1.0	Priority	Should-have
Requirement Category	Effectiveness	Relative WP	All Technical WPs
Requirement Name	Effectiveness	Relative Module	All PLOTO modules
Requirement Description	The System shall be understandable.	Relative Use Case/Scenario	Use Cases A, B, C
UR-9			
Version No	1.0	Priority	Should-have
Requirement Category	Effectiveness	Relative WP	All Technical WPs
Requirement Name	Effectiveness	Relative Module	All PLOTO modules
Requirement Description	The System shall work robustly (e.g., it did not freeze or crash).	Relative Use Case/Scenario	Use Cases A, B, C
UR-10			
Version No	1.0	Priority	Should-have
Requirement Category	Effectiveness	Relative WP	All Technical WPs
Requirement Name	Effectiveness	Relative Module	All PLOTO modules
Requirement Description	The System shall be an improvement compared to similar systems.	Relative Use Case/Scenario	Use Cases A, B, C
UR-11			
Version No	1.0	Priority	Should-have
Requirement Category	Satisfaction	Relative WP	All Technical WPs
Requirement Name	User satisfaction	Relative Module	All PLOTO modules
Requirement Description	The system shall be easy to use.	Relative Use Case/Scenario	Use Cases A, B, C
UR-12			
Version No	1.0	Priority	Should-have
Requirement Category	Satisfaction	Relative WP	All Technical WPs
Requirement Name	User satisfaction	Relative Module	All PLOTO modules
Requirement Description	The system shall be simple to use.	Relative Use Case/Scenario	Use Cases A, B, C
UR-13			
Version No	1.0	Priority	Should-have
Requirement Category	Satisfaction	Relative WP	All Technical WPs

Requirement Name	User satisfaction	Relative Module	All PLOTO modules
Requirement Description	The user shall feel comfortable using the system.	Relative Use Case/Scenario	Use Cases A, B, C
UR-14			
Version No	1.0	Priority	Should-have
Requirement Category	Satisfaction	Relative WP	All Technical WPs
Requirement Name	User satisfaction	Relative Module	All PLOTO modules
Requirement Description	The user shall could recover easily and quickly whenever making a mistake.	Relative Use Case/Scenario	Use Cases A, B, C
UR-15			
Version No	1.0	Priority	Should-have
Requirement Category	Satisfaction	Relative WP	All Technical WPs
Requirement Name	User satisfaction	Relative Module	All PLOTO modules
Requirement Description	The information (such as on-screen messages, and other documentation) provided with this system shall be clear.	Relative Use Case/Scenario	Use Cases A, B, C
UR-16			
Version No	1.0	Priority	Should-have
Requirement Category	Satisfaction	Relative WP	All Technical WPs
Requirement Name	User satisfaction	Relative Module	All PLOTO modules
Requirement Description	It shall be easy for the user to find the information needed.	Relative Use Case/Scenario	Use Cases A, B, C
UR-17			
Version No	1.0	Priority	Should-have
Requirement Category	Satisfaction	Relative WP	All Technical WPs
Requirement Name	User satisfaction	Relative Module	All PLOTO modules
Requirement Description	The system should have user-friendly interfaces that will be easy to use without prior experience.	Relative Use Case/Scenario	Use Cases A, B, C

4.5 PLOTO Process Requirements

The process requirements of the PLOTO platform are displayed below (Table 7).

Table 7: PLOTO Process Requirements

PR-1			
Version No	1.0	Priority	Could-have
Requirement Category	Law/Regulation	Relative WP	All Technical WPs
Requirement Name	Regulation (EU) No 546/2014	Relative Module	All modules
Requirement Description	The system shall be compliant with Regulation (EU) No 546/2014.	Relative Use Case/Scenario	Use Cases A,B
PR-2			
Version No	1.0	Priority	Could-have

Requirement Category	Law/Regulation	**Relative WP**	All Technical WPs
Requirement Name	Directive 2005/44/EC on harmonised RIS	**Relative Module**	All modules
Requirement Description	The system shall be compliant with Directive 2005/44/EC on harmonised RIS.	**Relative Use Case/Scenario**	Use Cases A,B
PR-3			
Version No	1.0	**Priority**	Could-have
Requirement Category	Law/Regulation	**Relative WP**	All Technical WPs
Requirement Name	Regulation (EC) No 414/2007	**Relative Module**	All modules
Requirement Description	The system shall be compliant with Regulation (EC) No 414/2007.	**Relative Use Case/Scenario**	Use Cases A,B
PR-4			
Version No	1.0	**Priority**	Could-have
Requirement Category	Law/Regulation	**Relative WP**	All Technical WPs
Requirement Name	Regulation (EU) 2018/974	**Relative Module**	All modules
Requirement Description	The system shall be compliant with Regulation (EU) 2018/974.	**Relative Use Case/Scenario**	Use Cases A,B
PR-5			
Version No	1.0	**Priority**	Could-have
Requirement Category	Law/Regulation	**Relative WP**	All Technical WPs
Requirement Name	Floods Directive (2007/60/EC)	**Relative Module**	All modules
Requirement Description	The system shall be compliant with Floods Directive (2007/60/EC).	**Relative Use Case/Scenario**	Use Cases A,B

At this point, it is important to mention that as the project evolves, the requirements list might get updated. If updates and/or changes occur, the final list of requirements will be presented in deliverable D2.2 “Definition of the Requirements, Use Cases and System Specifications final version”.

5 PLOTO system modules

The PLOTO system modules, as identified and described by the technical partners and providers (based on the template explained in Section 2.2.2), are presented in the tables below (Tables 8 to 20):

Table 8: Seismic Hazard

UID	**1**
Module Name	**Seismic Hazard**
Partner Responsible	NTUA
Module Description	Assess all potential seismic hazard scenarios and related ground motion fields per pilot.
Module Components	-
Sources	External earthquake alert service
Input Data	Seismic source model
Output	Scenario events, Ground motion fields
Consumer	Physical Vulnerability Model, Risk Assessment Engine
Tasks involved	T4.1
Added Value	Indispensible for IWAT

Table 9: Weather Hazard

UID	**2**
Module Name	**Weather Hazard**
Partner Responsible	AUTH
Module Description	Provide CFD simulation data, mesoscale model fore/now-casting, EuroCORDEX scenario data, and Frankenstein days downscaled information per pilot.
Module Components	-
Sources	Weather sensors
Input Data	Sensors, mesoscale model, CFD datasets, weather station data, EuroCORDEX
Output	Scenario events, weather intensity measure fields, forecasts and nowcasts
Consumer	Physical Vulnerability Model, Risk Assessment Engine
Tasks involved	WP3, T4.1
Added Value	Indispensible for IWAT

Table 10: Hydro Hazard

UID	**3**
Module Name	**Hydro Hazard**
Partner Responsible	End users
Module Description	Provide water elevation & return periods for all potential flood & drought scenarios.
Module Components	-
Sources	Hydro sensors

Input Data	Water elevation sensors, regional forecasts, hydrological model, precipitation sensors
Output	Scenario events, water level maps, forecasts and nowcasts
Consumer	Physical Vulnerability Model, Risk Assessment Engine
Tasks involved	T4.1
Added Value	Indispensible for IWAT

Table 11: Physical Vulnerability Model

UID	**4**
Module Name	**Physical Vulnerability Model**
Partner Responsible	SORECC
Module Description	Assess fragility and vulnerability curves for all assets of interest.
Module Components	-
Sources	None
Input Data	Asset exposure database, detailed structural drawings for Tier I assets, structural models
Output	Fragility and vulnerability curves
Consumer	Risk Assessment Engine
Tasks involved	T4.2
Added Value	Indispensible for IWAT

Table 12: Business Continuity Model

UID	**5**
Module Name	**Business Continuity Model**
Partner Responsible	SORECC
Module Description	Provide a business and organizational model for the pilot facility as well as a regional socioeconomic model for the surrounding areas.
Module Components	-
Sources	None
Input Data	Facility organization plan, personnel data, available business continuity plan, Business Interruption tables, Input-Output Regional economy tables
Output	Business performance per facility component/sector, economic performance per regional sector
Consumer	Risk Assessment Engine
Tasks involved	T4.5
Added Value	Indispensible for IWAT

Table 13: Risk Assessment Engine

UID	**6**
Module Name	**Risk Assessessment Engine**
Partner Responsible	NTUA
Module Description	Combine hazard and vulnerability data to assess the risk from all pertinent hazards.

Module Components	-
Sources	Seismic/Weather/Hydro hazard, Physical Vulnerability Model, Business Continuity Model
Input Data	All hazard data, all vulnerability data, all business continuity data
Output	Risk metrics per hazard scenario
Consumer	Physical impact, socioeconomic impact
Tasks involved	T4.3
Added Value	Indispensible for IWAT

Table 14: Physical impact

UID	**7**
Module Name	**Physical impact**
Partner Responsible	NTUA
Module Description	Assess the consequences of hazard events on the physical condition of all assets of interest.
Module Components	-
Sources	Risk Assessment Engine
Input Data	Risk metrics per hazard scenario, asset exposure
Output	Damage state, loss magnitude and downtime timeseries per asset
Consumer	Decision support system, IWAT
Tasks involved	T4.3, T4.5
Added Value	Indispensible for IWAT

Table 15: Socioeconomic impact

UID	**8**
Module Name	**Socioeconomic impact**
Partner Responsible	SORECC
Module Description	Assess the consequences of hazard events on the business and organizational aspects of the facility as well as the social and economic function of the surrounding areas.
Module Components	-
Sources	Risk Assessment Engine
Input Data	Risk metrics per hazard scenario, business continuity data
Output	Loss per organization parts, facility downtime and functionality timeseries, loss per socioeconomic sector, sector downtime and functionality timeseries
Consumer	Decision support system, IWAT
Tasks involved	T4.4, T4.5
Added Value	Indispensible for IWAT

Table 16: DigitalTwin

UID	**9**
Module Name	**DigitalTwin**
Partner Responsible	EXUS
Module Description	Provide digital representation of assets, processes and systems of the pre-defined area and predict location and time of future flooding, or droughtand related risks.
Module Components	-
Sources	Hydraulic and Hydrological models, 3D mapping software
Input Data	Digital Elevation model, satellite model, 3D building model, GIS data, water level data, weather data, sensor data
Output	Simulation of what-if scenarios that show the impact of flooding/drought on assets, processe and systems
Consumer	Decision support system, IWAT
Tasks involved	T6.8
Added Value	These simulations can be used to determine flooding or drought risks for existing conditions and to proposed mitigation strategies.

Table 17: Middleware and Data Fusion

UID	**10**
Module Name	**Middleware and Data Fusion**
Partner Responsible	RISA
Module Description	Collects, processes and provides data and information to other modules and applications in meaningful way. Incorporate current information systems (IWW, LEAs, Climate and Weather Forecast models, etc.), but also available sensor networks (mobile platforms, Satellite, GPS, cameras, weather-climate stations, etc.). Coordinate information delivery between control and device planes, accompanied by effective, scalable service assurance.
Module Components	**PLOTO middleware will consist of 6 modules:** • **Abstraction layer** in which the information from different sources will be available in the same format. This layer will provide uniform and transparent access to IWW data systems, services and sensor networks. • **Resources Management Framework/Fusion** provides components for storing, retrieving and managing metadata and data as well as for filtering, aggregation, and fusion of data. • **Event management, filtering and contextual information modules** will handle all the events from the data sources and will categorise retrieved events and information to proper categories for better understanding and processing from the PLOTO platform. Complex Event Processing (CEP) coupled with DF will be performed. • **Ontologies and Semantic representation layer** will create a base layer of common/standardised way of knowledge of the different IWW related resources/information with the proper metrics to be organised and create the connection between that info. Semantic interoperability will be created. • **Communication management module** in which all the appropriate

	interfaces/ protocols for the communication with the different data sources exists. • **Security and privacy module** that tackles with data and identity security and privacy aspects. **Data Fusion will consist of 3 layers:** • **Layer 1:** In this layer all the preprocessing of the different PLOTO data sources from sensors and information systems will be adapted to a uniform format for further processing for Layer 2. Layer 1 will be also responsible for data virtualization, meaning that virtual entities (objects) with logically similar attributes will be created from the data coming, without representing a specific data source. Raw data will be forwarded to Resources and Layer 1 activities will be performed in the Abstraction Framework part of the PLOTO middleware. • **Layer 2:** In this Layer the main DF and data processing will be performed by the PLOTO Resources Management/ Fusion framework. The main data processing will be done here focusing on data integration from various sources retrieved after the data preprocessing stage. **Four modules** will undertake this extensive procedure: **a) The Event Manager (EM), b) the DF Manager c) the CEP Engine and d) Reasoning Engine.** The data will be delivered as payload of events pushed by the EM that will work as an event broker. Such data will be collected and fused by the DF Manager, applying the stored DF-queries. As the fusion happens, new events can be generated from the query results, and can participate in further fusions to generate complex or aggregate data streams. This Layer will provide fused information through the Middleware API ready to be used for all DSS tools and for every specific application and module (Climate models, Geospatial Framework, Weather Forecast). Finally, raw data will be available to all high-level modules and applications for further application driven processing. • **Layer 3:** In this Layer DF related to specific application processing will be executed if needed in order to make available to operators and relevant authorities the data in meaningful way. The DSS will retrieve data from Layer 2 and will support decisions to the operators.
Sources	Input from WPs 3, 4 and 5.
Input Data	Input from WPs 3, 4 and 5.
Output	Output to WPs 4 and 6.
Consumer	Output to WPs 4 and 6.
Tasks involved	T6.4
Added Value	Collects, processes and provides data and information to other modules and applications, in meaningful way.

Table 18: IWW Assessment Tool (IWAT)

UID	**11**
Module Name	**IWW Assessment Tool - IWAT**
Partner Responsible	STWS
Module Description	IWAT will be a modelling and simulation environment for assessing the resilience of IWW and potential impacts assessment due to various hazards (e.g., drought, flood, extreme weather, etc.).

Module Components	IWAT will include authoring tools to design the IWW interdependences logic in terms of functional flow blog diagrams, a clearly defined plug-in mechanism where new algorithms/analyses can be added anywhere along the analysis workflow enabling scientists to create new end-to-end analyses or to enhance existing analyses, modelling various hazards impacts on IWWs, developing risk reduction strategies and implementing adaptation strategies to minimize their impact on societies.
Sources	All WP4 components
Input Data	impact assessment models (T4.5) Modelling tools WP3 scenarios/workflows
Output	impact & risk assesment results
Consumer	DSS & COP
Tasks involved	T6.1
Added Value	Several analyses, impact & risk assessment models could be combined in order to create end-to-end complex analyses workflows.

Table 19: Common Operational Picture (COP)

UID	**12**
Module Name	**Common Operational Picture - COP**
Partner Responsible	STWS
Module Description	All PLOTO information (climate data and services, fused and raw data from all kind of sensors (ground, space and UAVs), simulation results, vulnerability information as well as all IWW elements and metadata in terms of GIS information layers will be presented on COP.
Module Components	The COP will provide assistance to IWW and other land-infrastructure operators during maintenance as well as all phases of a crisis incident by providing all the available information regarding the current situation on a unified graphical user interface. By integrating IWAT, when it is fed with live data, it will be also used as a rapid assessment system.
Sources	T 6.4, T6.8
Input Data	All Data provided by middleware (data fusion layer) and the digital twin
Output	Common Operational Picture of the situation
Consumer	IMS/DSS, IWW and other land-infrastructure operators.
Tasks involved	T6.6
Added Value	The information that will be produced by the PLOTO components will be combined and depicted into the same screen/UI. This will improve the situation awareness of the users.

Table 20: Incident Management System (IMS) & Decision Support (DSS)

UID	**13**
Module Name	**Incident Management System & Decission Support - IMS/DSS**
Partner Responsible	STWS
Module Description	The IMS will be used by IWW operators to manage the day-to-day incidents and maintenance processes. It will also host on the same UI , the COP and the IWAT components.

Module Components	The IMS/DSS module includes the funcitonalities provided regarding both the Incident management (IMS) and the Decission support (DSS). • **IMS**: This is the component that helps operators manage daily routine incidents or maintenance tasks. The IMS will implement protocols for multiagency interaction and communication to integrate and synchronize actions of participating organizations and jurisdictions to ensure unity of effort. it will also permit the collaborative response of all involved relevant local and regional partners to efficiently implement response strategies in order to stabilize the incident and accelerate the transition to recovery. • **DSS**: The Standard Response procedures defined for every hazard will be integrated as a workflow of proposed actions or lists of proposed resources to be deployed.
Sources	T6.3, T6.6
Input Data	Standard Response Procedures, Common Operational Picture, Risk based planning capabilities, Mitigation solutions
Output	Incident Management and Decision Support Capabilities
Consumer	IWW operators
Tasks involved	T6.7
Added Value	Users will be able to be informed about the situation and manage the situation, taking the appropriate decisions. All these activities will be provided through a common UI, improving the users effectiveness.

At this point, it is important to mention that as the project evolves, the modules description will become more detailed and the updates will be presented in deliverable D2.2 “Definition of the Requirements, Use Cases and System Specifications final version”.

6 PLOTO use cases and scenarios

PLOTO will perform extensive tests in three different demo sites, in Belgium, in Hungary, and in Romania. The demonstration shall proof the suitability of the PLOTO platform for multiple hazard assessment and optimized operational and strategic decisions for management and maintenance of both IWW, considering hazards relevant for other sections of the same corridor, or for other critical parts of IWWs. The demonstration will focus on the following main objectives: 1) to improve multiple-hazard assessment and strategic management for protection of hotspots of the IWW ports and sections, 2) to improve strategic and operational decision making, 3) to test the various PLOTO outcomes and the overall integrated DSS tool with actuation technologies in real scale critical parts of the IWW.

IWWs operation is based on several assets and technologies, that we will try to taxonomize and identify, for all partners to have a common understanding of them. In doing this, the normative to IWW assets literature was reviewed and PIANC's 2020 report (PIANC, 2020) was identified and used as a basis. In this report, a comprehensive but not exhaustive inventory of inland waterways assets has been identified.

More specifically, to meet PLOTO's aim and objectives, and based on the IWW zones and areas (presented in Section 3.1), PIANC's inventory was processed. So, for each IWW zone and main zones' areas, the relevant sub-areas and main operations (per area) executed are identified and presented in the table below (Table 21).

Table 21: PLOTO's IWWs zones, areas, sub-areas and operations

Zone	Zone's Main Areas	Sub-Areas (critical for each area)	Main Operations (per area)
IWW Zone	Navigation Area	Channel / fairway / waterway (natural)	Pilotage Marker buoys navigation aids Dredging / disposal Maintenance of infrastructure Recreational use Sailing / water sports events
		Channel / fairway / waterway (maintained; dredged)	
		Dredged material aquatic disposal or placement site	
		Mooring areas (outside the harbour)	
		Anchorage	
IWW Port Zone	Navigation Area	Entrance channel	Pilotage Marker buoys navigation aids Dredging / disposal Maintenance of infrastructure Recreational use Sailing / water sports events
		Approach channel	
		Inner basin	
	Berthing Area	Berthing areas	Pilotage Berthing Marker buoys navigation aids Maintenance of infrastructure
		Reclaimed land areas	
Dry Port Zone	Quay Area	Dry dock	Cargo management ((un)loading)

Zone	Zone's Main Areas	Sub-Areas (critical for each area)	Main Operations (per area)
(related to freight terminal)	Riverside Transport Area	Cargo management area	Cargo transport Container and crew management Waste disposal Fuelling; re-fuelling; bunkering Shore-side power Scheduling Maintenance of structures Customs Migration Security
	Yard Area	Containers yard	
	Landside Transport Area	Storage facilities / Warehouses	
	Truck and Train Area	Handling cargo area	
	Gates	Waste management area	
	Other areas	Offices	
		Car Parking	
		Transport infrastructure (road, rail, etc)	
		Parking area	
		Access Management area	

To support their operations, IWW ports invest and maintain several assets such as piers, basins, stacking or storage areas, warehouses, cranes, stacking yards serviced by gantry cranes, as well as vehicles used to move containers around the terminal, such as straddle carriers. In the following table (Table 22), and based on PIANC's report, indicative assets operating in each area were identified and grouped in the following categories:

- Structures
- Physical systems and utilities
- Management and communication systems
- Plant and equipment
- Other Resources
- Interdependent services or systems

Table 22: PLOTO's IWWs assets per zone

Zone (Assets)	Assets Categories	Assets (per Asset Category)
IWW Zone Assets	Structures	Breakwater, wave chambers
		Dolphins
		Current deflector
		Storm surge barrier
		Aids to Navigation
		Fuelling; re-fuelling; bunkering barge
	Physical systems and utilities	Monitoring equipment, sensors, telemetry
		Scour protection
		River Information Systems

Zone (Assets)	Assets Categories	Assets (per Asset Category)
	Management and communication systems	Vessel Traffic Services (VTS)
		Automatic Identification Systems
		Tracking systems
		Incident management systems
		Administrative systems
		Communications infrastructure, e.g. radar, VTS
	Plant and equipment	Dredging plant
	Other Resources	Natural habitat features
		Archaeological or heritage resources
IWW Port Zone Assets	Structures	Revetment
		Quay wall
		Fenders
		Ladders
		Slipway
	Physical systems and utilities	Cathodic protection
	Management and communication systems	River Information Systems
		Vessel Traffic Services
		Automatic Identification Systems
		Tracking systems
		Incident management systems
		Administrative systems
		Communications infrastructure, e.g. radar, VTS
	Interdependent systems	Power stations or energy supply systems
		Water supply systems
		Waste water treatment systems
	Plant and equipment	Dredging plant
	Other Resources	Heritage resource (Lighthouse)
IWW Dry Port Zone (freight terminal) Assets	Structures	Distribution and storage centres
		Warehouses
		Paving
		Bollards
		Handrails
		Lighthouse
		Berth
		Terminal
		Cargo handling equipment, cranes
		Stock piles
		Ship lift
		Fuel station

Zone (Assets)	Assets Categories	Assets (per Asset Category)
		Reception facilities for waste disposal
		Bilge
		Hinterland connections (road, rail, waterway)
		Reservoir; associated channels or pipes
		Electricity sub-station
		Navigation aids
		Promenade, landscaping
		Boat yard
		Dry dock
		Dry stack
		Fences and gates
	Plant and equipment	Cranes
		Conveyor belt
		Syncrolift
		Onshore power supply equipment
	Physical systems and utilities	Monitoring system: VTS
		Drainage system
		Severage system
		Water supply system
		Electric supply system
		Shore-side power facilities
		Lighting system
		Monitoring equipment, telemetry
		Security systems; Closed Circuit TeleVision (CCTV)
	Management and communication systems	River Information Systems
		Vessel Traffic Services
		Weather stations
		Terminal Operating Systems
		Automatic Identification Systems
		Tracking systems
		Incident management systems
		Administrative systems
		Communications infrastructure (radar, VTS)
	Interdependent systems	Connecting road, rail or other transport infrastructure
		Power stations or energy supplies
		Water supply
		Waste water treatment
		Supply chain terminals
		Distribution and storage centres

Zone (Assets)	Assets Categories	Assets (per Asset Category)
	Other Resources	Natural habitat features
		Created or enhanced habitat features
		Archaeological or heritage resources
IWW Dry Port Zone (passengers terminal) Assets	Structures	Offices, buildings
		Warehouses
		Paving
		Bollards
		Handrails
		Lighthouse
		Berth
		Terminal
		Amenities, chandler, commercial, hotel
		Boat rental facilities
		Tour operator facilities (angling, wildlife watching)
		Stock piles
		Ship lift
		Fuel station
		Reception facilities for waste disposal
		Bilge
		Hinterland connections (road, rail, waterway)
		Reservoir; associated channels or pipes
		Electricity sub-station
		Navigation aids
		Promenade, landscaping
		Boat yard
		Dry dock
		Dry stack
		Fences and gates
	Physical systems and utilities	Drainage system
		Severage system
		Water supply system
		Electric supply system
		Shore-side power facilities
		Lighting system
		Monitoring equipment, telemetry
		Security systems; CCTV
	Management and communication systems	River Information Systems
		Vessel Traffic Services
		Terminal Operating Systems

Zone (Assets)	Assets Categories	Assets (per Asset Category)
		Automatic Identification Systems
		Tracking systems
		Incident management systems
		Administrative systems
		Communications infrastructure (radar, VTS)
	Interdependent services or systems	Connecting road, rail or other transport infrastructure
		Power stations or energy supplies
		Water supply
		Waste water treatment
		Supply chain terminals
		Distribution and storage centres
	Other Resources	Natural habitat features
		Created or enhanced habitat features
		Archaeological or heritage resources

PLOTO's initial IWW assets' inventory was shared with end-users (Use Case Leaders) that had been asked to check and update it, to reflect their own IWW needs. The inventory (as updated by end-users') will be discussed among relevant partners to dedicated meetings, and finally a PLOTO assets taxonomy will be created.

At the time of delivery of this report, a dedicated meeting has been conducted among "Use Case B: Budapest Port (inland) connected to the railway" relevant partners, technical partners and technology providers, and its assets inventory has been discussed. For consistency reasons, the final PLOTO asset's taxonomy (per Use Case) will be presented in deliverable D2.2 "Definition of the Requirements, Use Cases and System Specifications final version".

6.1 Use Case A: Danube Area, including the waterways and inland ports

In the following paragraphs, details related to Use Case A will be provided. Use Case A demonstration will be conducted in Danube area, which includes inland waterways and ports. The partners involved in this Use Case are the following:

- **AFDJ** - **Lower Danube River Administration**, as the national inland waterway administration may provide full set of qualified, official data on the sector Iron Gates II – Călărași (approximately 500 km), consisting of: Water levels, Water temperature, Bathymetric data
- **UDG – Danubius University of Galati,** Department: Danubius Institute for Business Strategies – socioeconomic studies, co-definition of research and market needs, business consultancy, IPR management, training and research dissemination.
- **RRT - Romanian River Transport Cluster -** inventory and mapping the situation in Galati ports, dissemination and facilitation of the discussion on the adaptation and mitigation measures in ports and the innovative business solutions and exploitation of project results.

6.1.1. Demonstration area's description (considered for the demonstration activities)

6.1.1.1. Demonstration area's location

The Danube River sector located between Iron Gate II (RKM 863) and Călăraşi (RKM 375), Figure 27, belongs to the lower basin of the Danube and is characterized by a very dynamic river bed with large flow rates (between 1600 m3/s and 15000 m3/s). The geography of this sector is diverse. It includes mountains, large plains, sand dunes, forested or marshy wetlands. Similarly, climate and precipitation vary significantly, and they continuously form the basin's landscapes. The morphological processes in the Lower Danube can be classified as very dynamic. In the upper part of the section (km 863 - km 730) the intensity of the erosion and accumulation is less then in the middle (km 730 - km 500) or in the lower part of the section (km 500-km 375). Hundreds of kilometres at the left and the right bank of the Danube River are eroded.

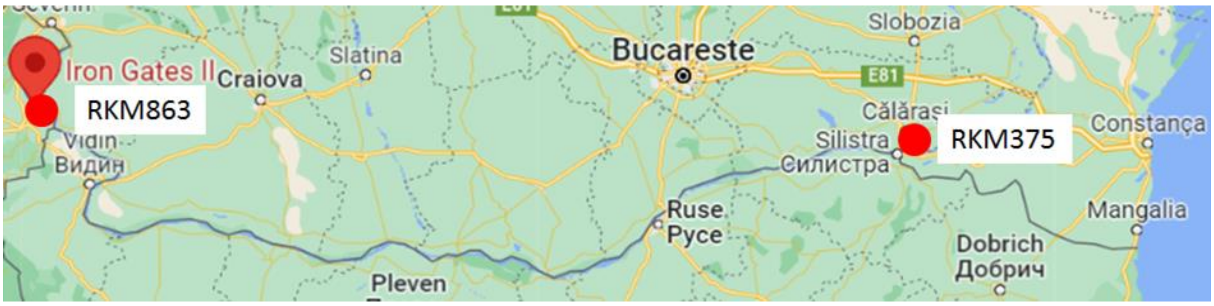

Figure 27: Map of the Danube River sector between Iron Gate II (RKM 863) and Călăraşi (RKM375), Use Case A (Figure processed from Google maps).

During the second half of the 20th century, close to three-quarters of the Lower Danube's floodplains were cut off from the main river by dikes and were transformed into agricultural areas, with subsequent impacts on flooding regimes. Besides of that, large parts of the Danube were experiencing river bed erosion due to gravel extraction, dredging, and dam construction, contributing to a lowering of water tables on adjacent agricultural lands. Eutrophication resulting from anthropogenic pollution has severely affected the Danube, and in particular the lower stretches of the river. Conversion of floodplain forest to agriculture and monoculture hybrid poplar plantations has led to more extreme flood events. Major flood events in the Danube River Basin of the recent past occurred in 2002, 2005, 2006, 2009, 2010, 2013, and 2014. On the other hand, the very low water levels reached in the lower Danube sector in recent years are damaging both the environment and the economy. Furthermore, the lowering of the water levels is followed by significant changes in their complexity on the riparian territories including the wetland zones.

The Lower Danube sector is impacted by four key drivers: agriculture, flood protection, transport, and climate change. These cause pressures including hydro morphological alterations, point and diffuse pollution, dams, barriers and locks, flow diversions and hydrological alterations. Climate change is expected to further increase flood risk all over the Danube sector, in terms of intensity, duration and frequency of events. There is also a higher possibility of flash flood events during dry periods. However, there is considerable uncertainty in the quantification of future flood events due to shortcomings in the estimation of future precipitation. Furthermore, climate change is increasingly causing hydrological, chemical and thermal stressors. Increases in temperature, evapotranspiration, and decreases in the amount of precipitation contribute to seasonal water scarcity in the delta, despite increasing river water inflow into floodplain lakes through drainage channels. As a result, this Danube River sector can suffer from low water levels – particularly in late summer and early autumn – with resulting impacts on ecosystem status and service provision to humans. According to some recent studies https://www.icpdr.org/main/publications/future-danube-river-basin, air temperature is expected to increase with a gradient in all Danube River Basin, starting from the northwest and coming gradually to the southeast. From 2021 to 2050, an increase of 4° C in the lower basin is expected. Between 2071 and 2100, an increase of about 5° C is expected. At the end of the century, the increase is expected to be particularly large during summer for the south-eastern region of the basin.

Previous studies (ISPA 2 project, 2009) indicate 38 critical sectors (Figure 28) with navigation constrains of which 21 remain still critical sectors at present, as follows: CS1 (Salcia, rkm 825-819), CS2 (Basarabi, rkm 804-797), CS3 (Bogdan/Săceanu Island, rkm 787-781), CS4 (Artchar, rkm 768-764), CS5 (Pietrisul Island, rkm 760-755), CS6 (Nebuna Island, rkm 787-781), CS7 (Lom-Linovo Island, rkm 745-735), CS8 (Nebuna Island, rkm 728-721), CS10 (Carabulea Bechet/Oriahovo, rkm 679-673), CS12 (Corabia-Baloiu Branch, rkm 633-625), CS13 (Kalnovats, rkm 615-607), CS14 (Lakat/Paletz Island, rkm 591-581), CS15 (Belene Island upstream, rkm 577-560), CS17 (Vardim Island, rkm 548-540), CS18 (Gaska-Vardim Island, rkm 540-536), CS19 (Batin Island-Stilpiste, rkm 530-515), CS20 (Kama and Dinu Islands, rkm 512-504), CS22 (Giurgiu, rkm 590-486), CS25 (Lungu Island, rkm 470-467), CS28 (Kosui, rkm 426-420), CS31 (Varasti Island, rkm 400-399). The crossings (bottlenecks) have a tendency to become a limiting factor for the navigation.

Figure 28: Critical sectors identified on the Danube, between Iron Gate II (RKM 863) and Călăraşi (ICPDR IKSD, 2009)

6.1.1.2. Demonstration area's operations and stakeholders involved

In the inland sector related to the case study, seven port areas are to be mentioned (Moldova Veche, Drobeta Turnu Severin, Orsova, Calafat, Oltenita, Giurgiu si Calarasi) of which Turnu Severin, Calafat, and Giurgiu is part of the Rhine-Danube Corridor. Port infrastructure and land are state owned and administrated by a state owned company, the Lower Danube Ports Administration. The fairway along all Romanian sectors of the Danube River is administrated by the River Administration of the Lower Danube. Port, logistic and transport services are provided by private operators.

The main port located on the envisaged section is Giurgiu (Navigation Area: km 489-497) which can accommodate and operate freight and passenger vessels. Port facilities consist of a berthing area of 1850 m length, two inner basins (1290 m), one oil berth (600 m), shore side electricity, ship waste reception, ship repair, custom, ferry-boat, road and rail hinterland connections. Logistic services are available in Free Zone area, close to port area. Port services (transhipment and storage) are provided by private port operators: SCAEP Giurgiu Port, DUNAPREF.

Drobeta Turnu Severin (navigation Area: km 927-934) is the second port in terms of importance on the concerned navigation sector, which can accommodate and operate freight and passenger vessels. Port facilities consist of a berthing area of 1100 m length, bunkering berth, silos, ship repair, shore side electricity, ship waste reception, custom, road and rail hinterland connections. A multimodal terminal is foreseen to be constructed. The project is one of strategic project selected by EC on CEF project list. Port services (transhipment and storage) are provided by private port operator TRANSEUROPA PORT.

Orsova port (navigation Area: km 953-957) is a smaller port (600 m waterfront) but there is a modern passenger terminal. It can provide freight transhipment, water and energy supply, ship waste reception and is connected to city by road. Port operator is SCEP DROBETA.

Calafat port (navigation area: km 793-796) is serving the cross-border traffic (Calafat-Vidin) between Romania and Bulgaria. It provides also a passenger berth and two berth for freight transhipment. Port operators are DUNAGRICOL LOGISTICS&SHIPPING LTD, DUNAGRICOL JSC, CEREALCOM JSC.

Oltenita (navigation area: km 428-43) provide freight transhipment services (berth of 300 m) with road and rail access. Port services are provided by SCAEP GIURGIU JSC and TTS BUCURESTI JSC.

Calarasi port (navigation area: km 372-377) is serving the cross-border traffic (Calarasi Chiciu-Silistra) between Romania and Bulgaria with direct road connection to A2 motorway (Bucuresti-Constanta). Port operators are AGROVET LTD, MERIDIAN LTD.

Transport services are provided by private operators among which the most important is NAVROM JSC which operate the biggest fleet on the Danube including international transport. Besides this, other transport operators are GIURGIUNAV JSC, METALTRADE LTD, ROMNAV JSC.

Port operators and transport operators are represented by two NGO’s: Union of Romanian Inland Ports and Romanian Association of port and inland transport operators. Both are consultancy organization for the Romanian Ministryof Transport. The Union of Romanian Inland Ports association also represents Romanian port operators at international level as a member of the European Federation of Inland Ports.

6.1.1.3. Demonstration area’s landscape and environmental conditions’ description

The Danube sector Iron Gates - Călărași (the meadow sector) is characterised by a wider riverbed, with an average of 800 m width, thus forming a wide meadow on the Romanian shoreline. The Holocene meadow, formed as a result of sediment transport and accumulation, increases in width from upstream to downstream, from 3-4 km at Drobeta Tr. Severin to 16-17 km at Calarasi. In longitudinal and transverse profiles, the meadow shows a microrelief made up of stripes: the layer of fluvial gravels, the area of lakes and marshes (low-level area), and the meadow terraces (high-level area) with port cities such as Dr. Tr. Severin, Calafat, Tr. Magurele, Zimnicea, Giurgiu, and Calarasi.

The suspended sediment loads vary depending on seasonal fluctuations, from a concentration of 0.05 mg/L, in the spring season, to 0.01 mg/L during the rest of the year. Large deposits of sediments are recorded in areas where the water current is reduced, particularly in small bays. Thus, the Danube sector downstream of Iron Gates I and II, until Giurgiu, is also called ‘’Danube sand area’’, which generates poor bottom biocenosis due to the abrasive action of the sand. Occasionally, within this sector, the water flow gathers the sand and forms dunes, behind which oligochaetes, crustaceans, molluscs, and insect larvae gather.

Due to climate change, the water temperature in the lower sector of the Danube River manifested a general upward trend in the last years, from 2007 until the end of 2022 and the beginning of 2023, respectively. One of the ports was observed this upward trend is Gruia port, where an average increase of water temperature of over 7% during the winter period, while for the Corabia and Calarasi reference points, the average water temperature increased by over 25% and 17%, respectively, if the year 2007 is compared to 2022-2023. The maximum and minimum values of water temperature of all 3 reference points are presented in Table 23, for the year 2007 vs. 2022-2023. It can be emphasised that the extreme temperature range is wider in 2022-2023, compared to 2007, a fact valid for all 3 reference points.

Table 23: The extreme values of temperature and water level for all three reference points, in 2007 vs. 2022-2023 [1, 2, 3]

Period	Water temperature (°C)			Water level (cm)		
	Gruia	Corabia	Calarasi	Gruia	Corabia	Calarasi
January 2007	Min. 3.5 Max. 5.5	Min. 4.2 Max. 5.8	Min. 3.7 Max. 5.5	Min. 12 Max. 413	Min. 12 Max. 231	Min. 4 Max. 200
January 2023	Min. 4.5 Max. 6.5	Min. 5.00 Max. 6.00	Min. 5.2 Max. 6.5	Min. 174 Max. 422	Min. 157 Max. 281	Min. 160 Max. 254
November 2007	Min. 5.0 Max. 11.0	Min. 5.0 Max. 12.0	Min. 5.5 Max. 12.0	Min. 12 Max. 413	Min. 12 Max. 231	Min. 4 Max. 200
November 2022	Min. 9.0 Max. 12.0	Min. 10.5 Max. 14.0	Min. 10.0 Max. 15.3	Min. 94 Max. 304	Min. -55 Max. 236	Min. -80 Max. 150
December 2007	Min. 5.0 Max. 5.1	Min. 4.0 Max. 5.5	Min. 4.8 Max. 5.5	Min. 140 Max. 425	Min. 146 Max. 329	Min. 148 Max. 309
December 2022	Min. 4.5 Max. 9.0	Min. 5.0 Max. 10.0	Min. 5.0 Max. 9.0	Min. 106 Max. 428	Min. 95 Max. 349	Min. 85 Max. 318

The water level shows an increasing trend in Gruia, ranging between 12.00 – 30.71%. However, for Corabia and Calarasi the increasing trend of water level is manifested only during November, 16.66% and 68.88%, respectively. This can be due to several extreme floods that occurred in some area of the Lower Danube River, during 2022-2023.

The fish diversity in the Lower Sector of Danube River recorded a decreasing trend, during the years 2007-2022 and the total capture of peaceful (non-ichthyophagous) fish species are higher compared to raptor (ichthyophagous) fish species. Negative correlation between water level and temperature, as well as between water temperature and fish diversity. These findings are confirmed also by a recent study [4], conducted in the Danube downstream sector limited between Braila and Tulcea reference points.

6.2 Use Case B: Budapest port (inland) connected to the railway

In the following paragraphs, details related to Use Case B will be provided. Use Case B demonstration will be conducted in Budapest port, which is connected to the railway network. The partners involved in this Use Case are the following:

- **BSZL - Freeport of Budapest Logistics Ltd.:** coordination and operation of trimodal (waterway, railway, road) logistics services, data provision
- **MÁV – Hungarian State Railway Company:** providing accessibility to railway network and related services, data provision

- **RSOE – National Association of Radio Distress-Signalling and Infocommunications:** connection to shipping and port information system, data provision and analysis
- **BME – Budapest University of Technology and Economics, Department of Transportation Technology and Economics:** situation analysis, consultancy activity, survey of user requirements, discussion on the adaptation and mitigation measures, training, socio-economic studies, and innovative business solutions, demonstration and validation activities, dissemination, and exploitation of project results

6.2.1. Demonstration area's description (considered for the demonstration activities)

6.2.1.1. Demonstration area's location

The port is located in the Central region of Hungary, within the boundaries of the capital city Budapest (Figure 29). The port has been established in the first third of the 20th century, when that area was still considered as suburb. Then, a strong industrialization and population growth occurred in the 1950s. Consequently, the city surrounded the port; thus, the port's development possibilities are limited recently, and its approach is difficult. The port is accessible via one railway connection and from two main road directions. Establishment of the M0 motorway (ring road around Budapest) in the 1990s significantly improved the road connection quality, but the traffic must pass the 21st district of Budapest (called Csepel) causing harmful environmental effects there and congestion to reach the motorway. As the waterway network in Hungary is not very dense, the port serves not only the capital city with approximately 1,7 milion inhabitants, but the entire central-Hungarian region with approximately 3,5 million inhabitants.

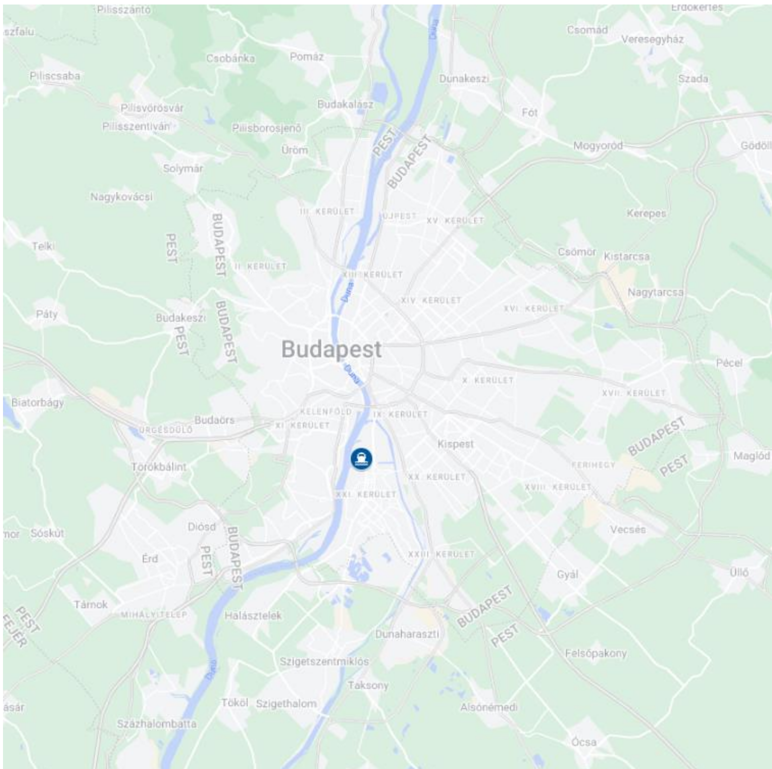

Figure 29: Location of the Freeport of Budapest

6.2.1.2. Demonstration area's operations and stakeholders involved

The Freeport of Budapest covers approximately 108 hectares. It is operated by BSZL Zrt., and provides fully comprehensive port services. In the three operating basins, a total of 18 berths have been established. More than 157 000 square meters of covered storage space is available in the Port area. Fully comprehensive rail and shipping services are available. The Port was certified as a national public port in 2005. The Port is considered as an internationally significant port and logistics centre. It is the only significant trimodal container terminal of the country.

The length of railway network within the Port is 15.47 km. It is connected to the network of the Hungarian State Railways with a connecting track branching from the marshalling yard called 'Budapest-Soroksári út'. Permitted axle load is 20 tons.

The container terminal's area is 104,000 m² for container storage, which is covered with concrete. Its annual traffic is 175,000 TEU. The storage capacity (loaded + empty) is 5,800 TEU. Main parameters of road connection: trucks approach the Port from M0 (ring) motorway, which is located 8 km away towards southern directions.

The railway connection of the Freeport of Budapest is provided through the Gubacsi railway bridge via the marshalling yard called 'Budapest-Soroksári út'. The yard is connected to the TEN-T main network through no. 150 railway line. Freight traffic from/to the port passes through Ferencváros marshalling yard, which is the biggest yard in Hungary with 80 tracks. Trains toward the west (Vienna), south (Kelebia-Beograd), and east (Záhony-Ukrainian border) should pass through Ferencváros marshalling yard. Significant bottlenecks of the railway infrastructure are the Gubacsi bridge (max 5 km/h speed and 20 t axle load) and the Corvin junction (level crossing blocking the road traffic). The railway network of the study area is depicted in Figure 30.

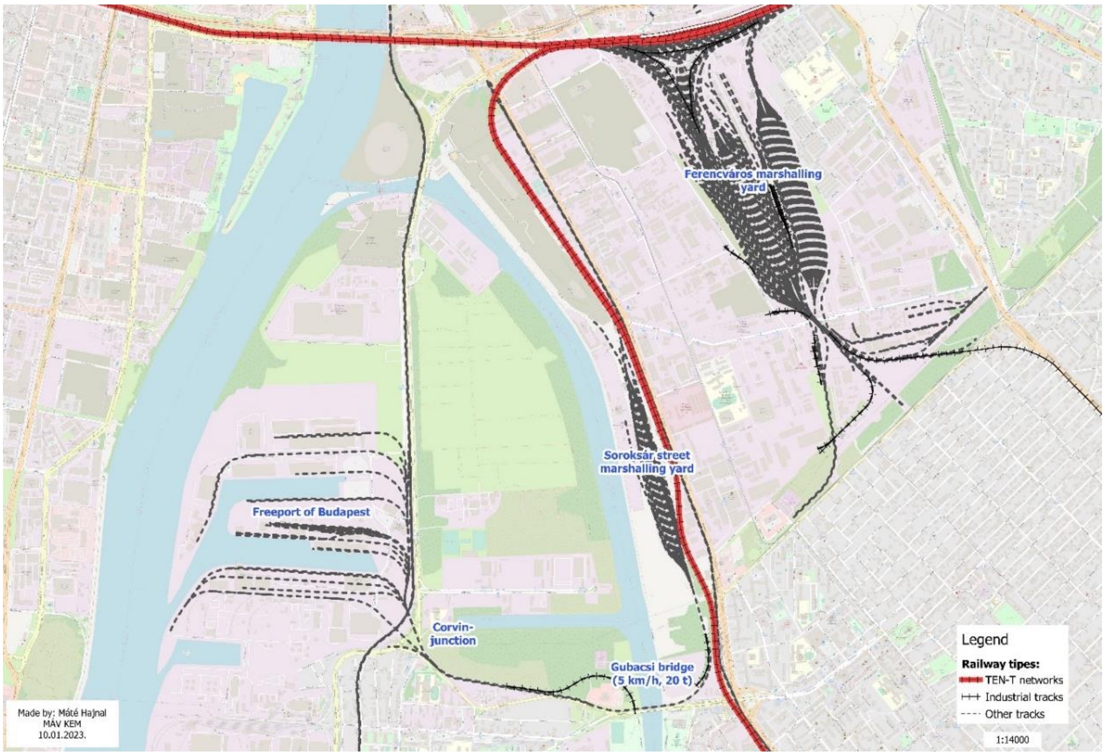

Figure 30: Railway network in study area Budapest

Besides the usual business administration and security systems of the port, the national Port Management Information System (KIR system – portinfo.hu, Figure 31) was developed in 2022 and it is in use by the port dispatcher service of BSZL as a pilot system. The main services of the KIR system are the following:

- Vessel traffic monitoring and electronic logs;
- Communication with vessels and trucks;
- Cargo loading monitoring, statistics and data provision;
- Calculation guide generation on port fees;
- Container plan elaboration;
- Automatic notification if vessel arrives and information on ETA;

PLOTO alerts and notifications could be integrated into the KIR system.

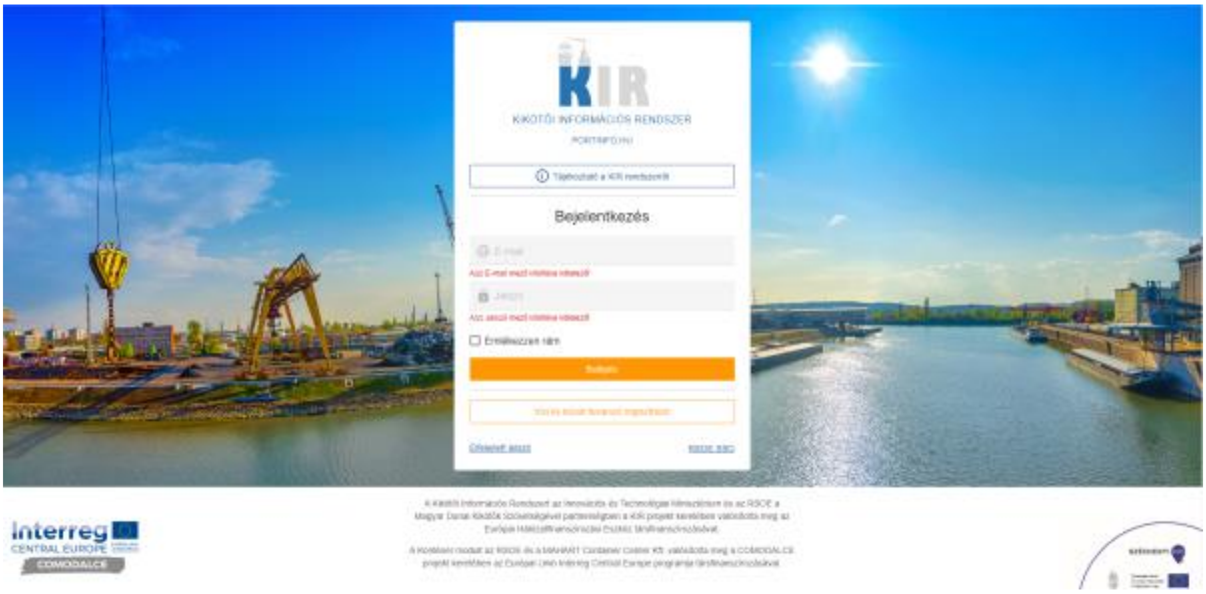

Figure 31: KIR system (portinfo.hu)

According to the 2005/44/EC Directive, River Information Services (RIS) system was deployed in Hungary for the Danube. The Hungarian RIS system, called PannonRIS (pannonris.hu) is a complex system including AIS, radar, CCTV and meteo subsystems and all relevant services like tracking and tracing, notices to skippers, electronic navigational charts and electronic ship reporting.

6.2.1.3. Demonstration area’s landscape and environmental conditions’ description

The port is located on the North edge of the Csepeli-plane. The plane extends in Bács-Kiskun, Fejér and Pest counties, and Budapest counties. Its total area is 1257 km^2. The region has a moderately warm, dry continental climate. The annual duration of sunlight is around 2000 hours in the North parts and close to 2050 hours in the south parts. The average annual temperature is 10.3°C. The average maximum temperature over many years is 34.5°C, and the average minimum temperature is –16.3°C. The annual precipitation is 530-550 mm in the North and central part – where the port is located, elsewhere 550-580 mm. The aridity index is 1.28-1.32 in the North parts and 1.21-1.28 in the South parts. The prevailing wind direction is North-West, the average wind speed is 2.5-3.0 m/s. Due to its location, the port is strongly exposed to the wind.

Terrain: The plane is an alluvium floodplain with an altitude of 94.4 and 126 m above sea level. The typical surface height is 110 m in the north and 96-100 m in the south. The average relief is 4 m/km^2 reducing from the north to the south. The alluvium is divided into terraces descending to the South and to the Danube. The low-flood area is 4-6, the high-flood area is 6-10, and a few terraces are 12-16 m higher than level 0, which is the level of the Danube. The western part of the plain was mainly formed by river erosion and accumulation effects. The surface is covered with a dense network of abandoned meanders. Besides meanders, there are patchy coastal dunes. In the flood plain, there are several blocked holes with poor drainage. On the eastern edge of the plaine, there are some quicksand surfaces.

Geography: The petrographic composition of the substrata fragmented along the structural line varies; it is made up of different Paleozoic-Mesozoic formations. In the south, there is a sequence of rhyolitic-dacitic facies from the Miocene volcanism in the deep. The 10-20 m thick gravel layer is located close to the surface, is a good water reservoir and constraints a significant amount of usable gravel. Another gravelly sediment is located between Bugyi and Kiskunlacháza where a large, 6-10 m thick deep gravel terrace covered with thin sand is located. The most extensive gravel reserves are located in Szigetszentmiklós, Bugyi, Kiskunlacháza, Délegyháza, Adony, Dunavarsány and Halásztelek. Holocene formations cover a significant part of the surface. Due to the Danube's efficient sediment transfer activity, the Old and New Holocene formations often accumulated next to each other at the same levels. Several Pleistocene elevations covered with quicksand are located in the eastern part of the plain.

Water: The plain is located along the Danube starting 57 km downstream from the beginning of the tributary Soroksári (Ráckevei) Danube branch to Rácalmás (located in the south). The estuary sections of the streams are in this section the following: Hosszúrét stream - 21 km, Benta stream – 54 km, Szent László stream – 68 km, Váli stream – 56 km. The Soroksári-Danube branch has estuary sections of canals (Gyáli main canal – 32 km, Danube-Tisza canal, 39 km, North belt canal – 36 km); these canals are not navigable; their main purpose is agricultural watering. The Danube valley canal collects the seasonal waters on the eastern edge of the plain. The plain suffers from water scarcity. Dams control the water flow and water level in the canals and in the Soroksári-Danube.

The water traffic is constant in the main Danube and determined according to the capacity of the locks (Kvassay and Tassi) in the Soroksári-Danube. 36 lakes are found in the plain; natural lakes, oxbow lakes (after the Danube regulations), fishponds, reservoirs, quarry ponds. 27 natural lakes cover 72 ha. Among the artificial lakes, the biggest ones are the quarry pond in Délegyháza and the fishpond in Lívia. The three reservoirs cover 357 ha. There are three oxbow lakes covering 36 ha. From the point of view of flood protection, the plain is considered exempted. Dams are located along the Danube and Sorkosári-Danube branches. The length of the canal network managing the inland water exceeds 800 km. The typical average distance from the terrain level to the groundwater table is 2-4 m, but in the north part, where the port is located, this distance is higher. The groundwater contains mainly calcium, magnesium, hydrocarbonate, and, in some cases, sodium. The composition shows no particularities. The number of artesian wells is large as the hydraulic head is often above terrain level for the main aquifer in the region. The part of the plain along the Danube belongs to the groundwater body used for drinking water abstraction for the city of Budapest; therefore, the water quality protection requires special attention.

6.3 Use Case C: Region of Wallone in Belgium

In the following paragraphs, details related to Use Case C will be provided. Use Case C demonstration will be conducted in the Walloon region in Belgium. It focuses on a section of an IWW (between Liège and the Belgian-Dutch border and on the assets in the hinterland potentially at risk in case of dike breaching along the IWW. The partners involved in this Use Case are the following:

- **Service Public of Wallonie (SPW MI):** Provision of field data and access to facilities for testing solutions
- **University of Liège (ULiege):** Processing and analysis of data, hydrodynamic modelling, impact analysis

6.3.1. Demonstration area's description (considered for the demonstration activities)

6.3.1.1. Demonstration area's location

The area of interest for Use Case C is located in the Walloon region in Belgium downstream of the city of Liège. Here, our focus lies on a section of the river Meuse up to the Belgian-Dutch border and the part of the Albert Canal, which is more or less parallel to the river Meuse as well as the associated floodplain of both, where the relevant assets of Use Case C are located. The floodplain and all its assets are especially interesting to analyze in the context of dike breaching scenarios, as such an event would have devastating consequences on infrastructure, buildings, and people in the region.

Figure 32 displays the situation of the area of interest of Use Case C within the international basin of river Meuse. The topography of the basin of river Meuse as well as the main weirs along river Meuse are also represented. The Albert canal is not explicitly shown in Figure 32, but it is represented in Figure 33 and Figure 34. It runs parallel to the Meuse between Liège and the Belgian-Dutch border (Figure 33/B). Over this section (i.e., downstream of Liège), river Meuse itself is not navigable and shipping takes place on the Albert canal. Just before reaching the Belgian-Dutch border, the Albert canal turns towards the north west to reach the sea harbour of Antwerp (Figure 33/A). Details of the configuration of the IWW stretches in and around Liège are visible in Figure 33/C and Figure 33/D.

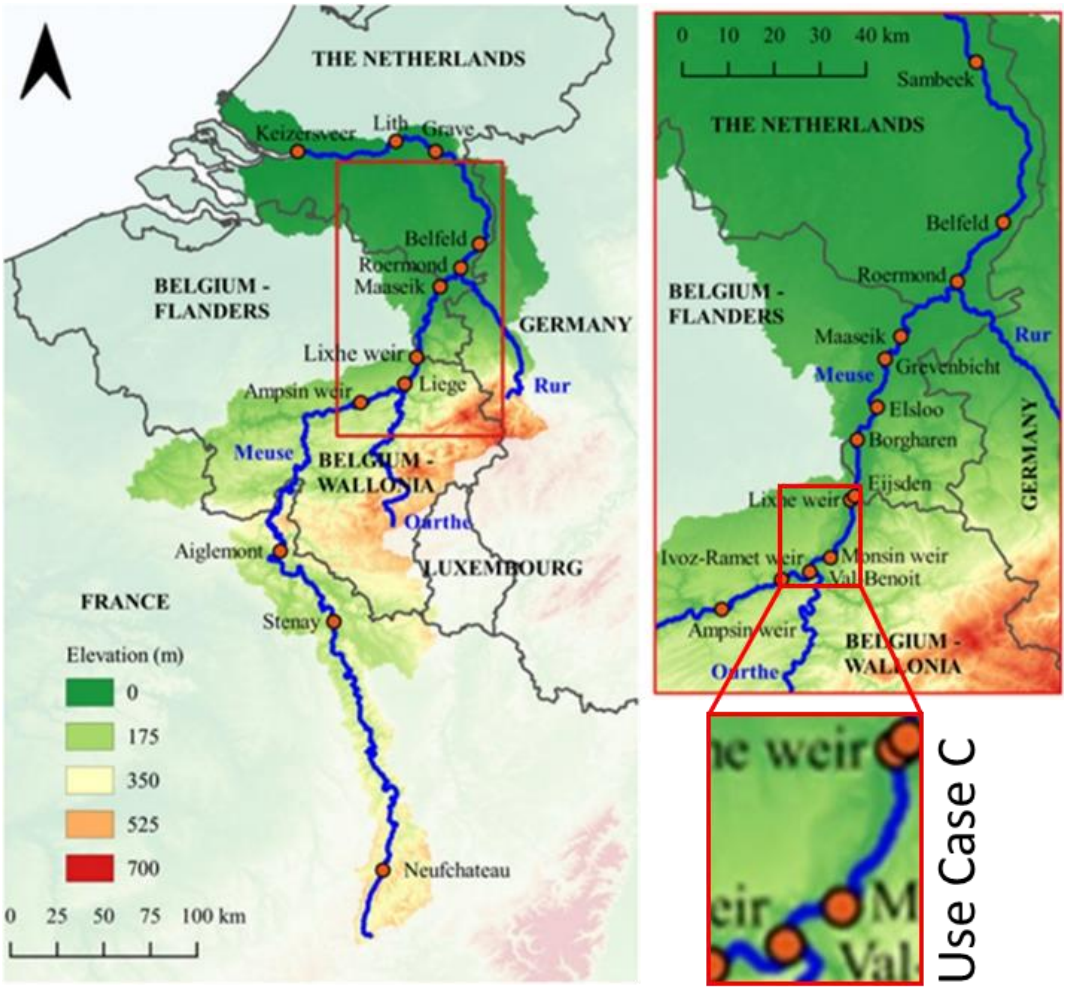

Figure 32: Overview of the study area of the Use Case C including the Meuse, Ourthe, and Rur rivers, as well as the catchment topography of river Meuse, national borders, and the main weirs (Figure is taken from Kitsikoudis et al. (2020))

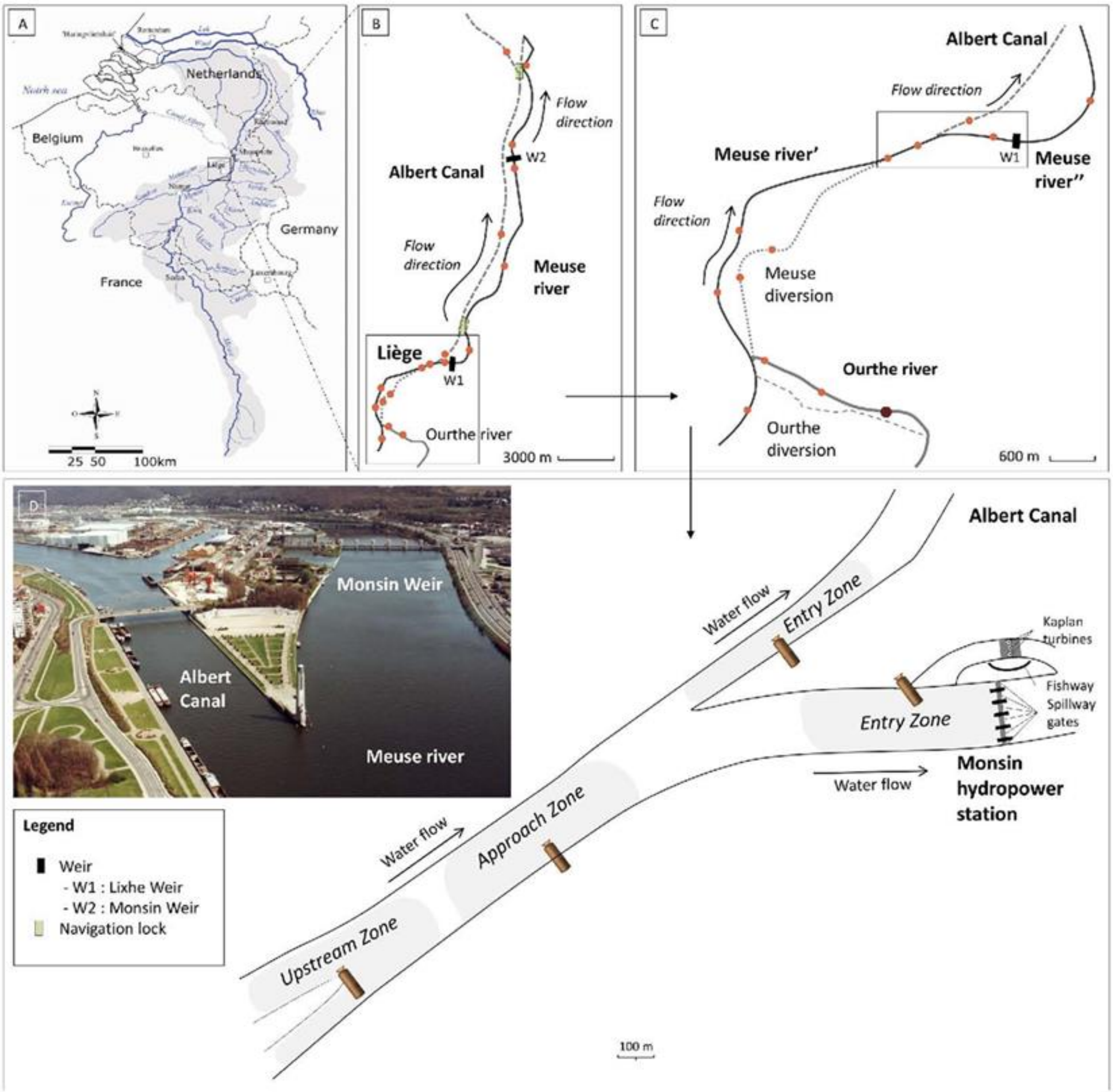

Figure 33: Division between river Meuse and the Albert canal in Liège. (A) International Meuse basin covering parts of France, Belgium, Luxembourg, Germany and The Netherlands. (B) Studied Meuse river and Albert Canal stretches. (C) Meuse and Ourthe river stretches upstream of the entrance of the Albert canal. (D) Photographic (©SPW-Direction des Voies Hydrauliques de Liège) and schematic representations of the division between river Meuse and the Albert canal downstream of Liege, with Monsin weir and hydropower plant. Adapted from (Renardy, et al., 2021).

6.3.1.2. Demonstration area's operations and stakeholders involved

Context

The study area of Use Case C is an important component of the IWW network of the Walloon region in Belgium. Overall, there are 450 km of IWW infrastructure in the Wallon region, which are of great international importance. Roughly one third of the traffic is in transit, while the rest of the share is composed of import and export. Additional challenges und usages other than traffic need to be considered. Among others, several hydro power plants are located along the river Meuse and the Albert Canal. Both upstream and downstream of Liège water from the river is abstracted for drinking water purposes as well as it serves for cooling a nuclear power plant. In this Use Case C, the main waterway is the Albert canal. We focus on the section of the canal, which is prone to dike breaching, and which is the water course displayed in Figure 34 on the west side of river Meuse.

Asssets-at-risk in the hinterland

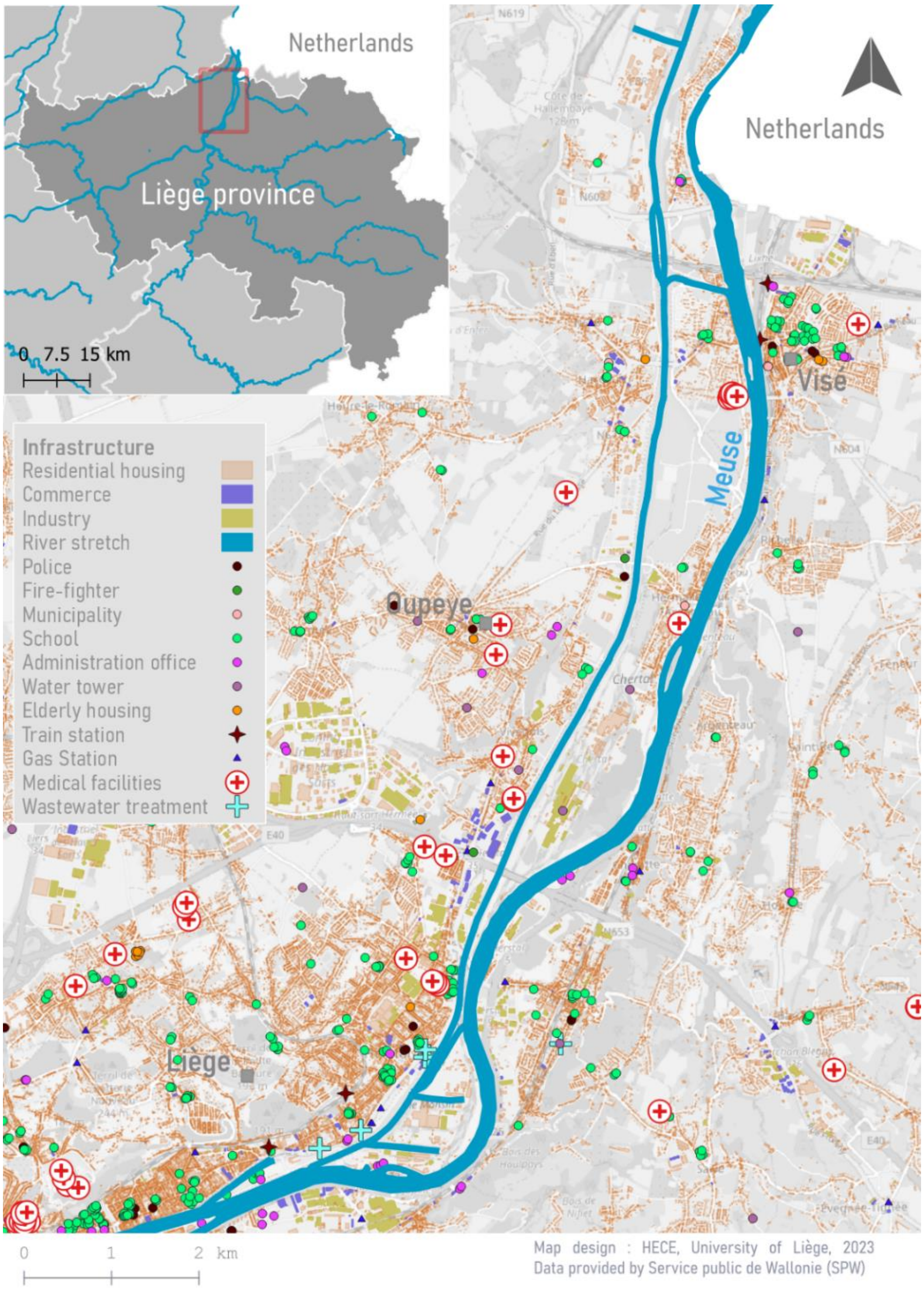

Figure 34: Land use of the area of Use Case C

The map displayed in Figure 34 shows different types of land uses, assets, stakeholders in lumped categories, and infrastructure elements which are present in the area of interest (i.e., the IWW and the floodplains potentially affected in the event of breaching of a dike of the IWW). As Use Case C focuses on the risks associated to dikes and embnakments along river Meuse and the Albert canal, the assets and infrastructure elements we consider are those which are endangered by a hypothetical dike breaching scenario. When it comes to the assets in our Use Case C, we consider infrastructure, transport, people and their belongings in the hinterland located in the floodplain. The most common usage of land is residential housing as the endangered area is home for many people. Besides housing, industry and commerce are also common in the area. Several industries storing and dealing with hazardous substances are present, which may induce spill in case of a dike breaching event due to the associated inundation. Similar risk exists for waste-water treatment plants and gas stations, which are also present in the area. Critical infrastructure elements for society are present like police and firefighters stations, municipality and administration offices, as well as train stations or water towers. The floodplain comprises schools and residences for elderly people as well as medical facilities, which would require a high priority for evacuation.

Transportation infrastructures in the hinterland

In Figure 35, relevant transportation infrastructure in the area of Use Case C is depicted. The waterways comprise the Meuse river (water course on the east side) and the Albert (waterway on the west side), which is a critical waterway for shipping downstream of Liège towards the port of Antwerp. Besides these two main water courses, the port of Liège is visible in the southern part of the map in Figure 35, as well as Monsin weir and lock. There is also a dense network of railways, highways, national roads as well as electrical power lines which functionality may collapse in case of an inundation event. Moreover, industries producing or dealing with hazardous substances are depicted classified into two categories of higher and lower threat to the people and the environment in case of a spill.

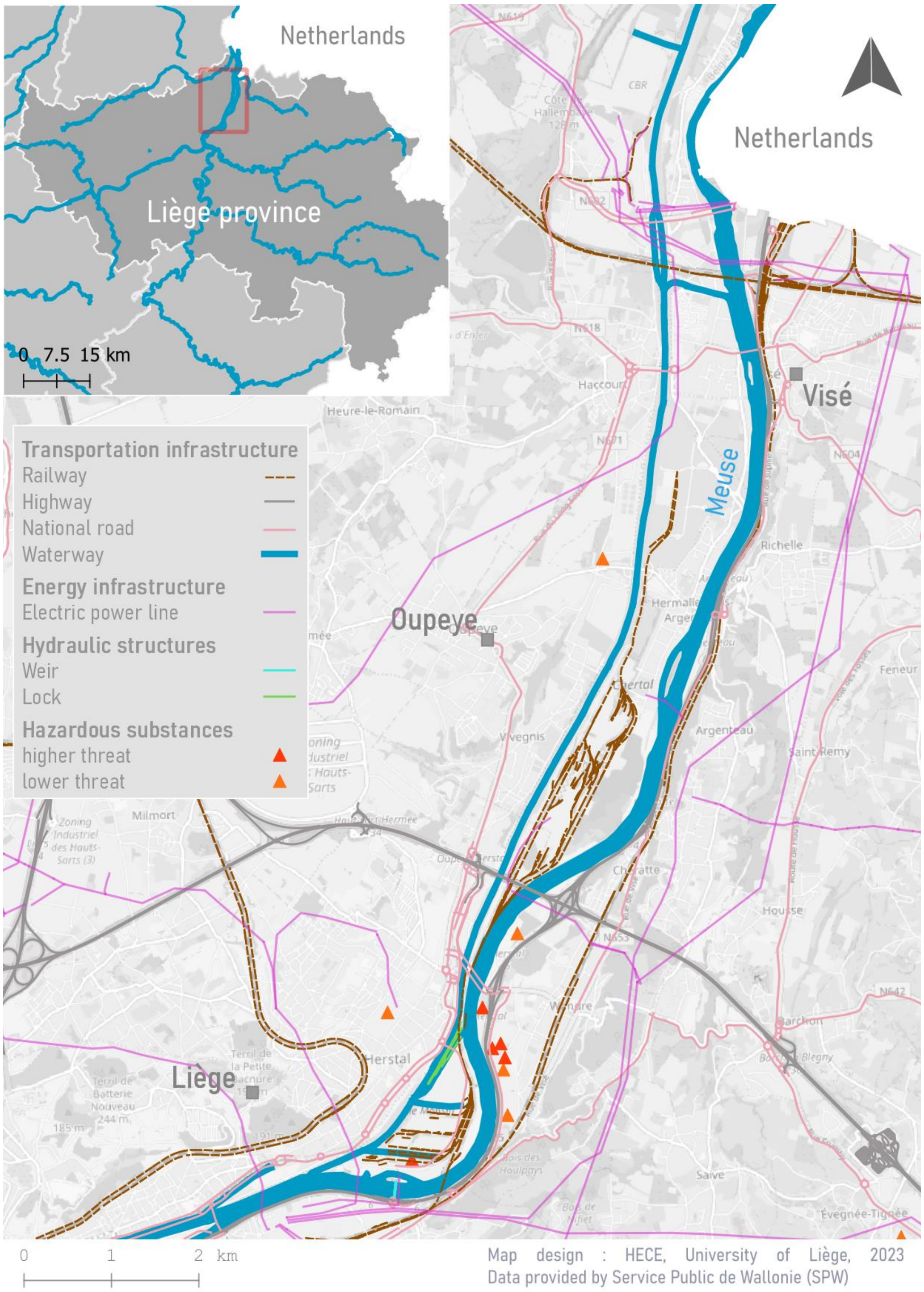

Figure 35: Transportation infrastructure in the area of Use Case C

6.3.1.3. Demonstration area's landscape and environmental conditions' description

The area of interest in Use Case C is highly urbanized and densely populated. Most of the urbanization, residential buildings as well as industrial facilities are in the floodplains as, beyond the floodplain, the middle mountains limit extensive urbanization due to steep hill slopes.

Land Usage

The map shown in Figure 36 displays the land usage and soil cover in the area. The Albert Canal (waterway on the west side) and the river Meuse (water course on the east side) are visible. In the southern part of the map, one sees a high degree of urbanization which corresponds to the outskirts of the city of Liège, including its port and related infrastructure. Overall man-made constructions and grass land are dominant in the floodplain, while some smaller pieces of forest are visible as well.

Topography and waterway characteristics

As can be seen from the topographic map in Figure 37, the area is located within middle mountain ranges, which are the foothills of the Ardennes.

Figure 37 shows the locations of four relevant weirs, and a picture of the two weirs directly located in the core area of interest (labelled by 1 and 2). Stage-discharge curves at these weirs will be used in the hazard modelling to be conducted The Albert Canal and the river Meuse are flanked by dikes and embankments over a substantial portion of their course through the study area. The narrow valleys present in the study area together with highly constructed river channels provide only limited water storage capacity (Kitsikoudis, et al., 2020) compared to more freely meandering streams in wide floodplains present in other parts of the Meuse basin as well as in other regions of Europe like Hungary or Romania. However, the highly constructed nature of the river Meuse in its present state, allows for a highly regulated water level. This is especially advantageous in low-flow conditions, as an appropriate water level for shipping can be guaranteed. The water level is generally not an issue in low flow conditions, but water consumption due to the operation of navigation locks is the main concern during low flows along river Mesue in Belgium.

Hydrology

The Meuse river is fed by a trans-national basin including parts of Belgium, France, Luxemburg, Germany and the Netherlands (de Wit, et al., 2007; Kitsikoudis, et al., 2020) having an overall area of approximately 33,000 km^2 (de Wit, et al., 2007). The Belgian part is characterized by narrow valleys shaped by the river within the Ardennes massif featuring steep hill slopes due to the Peleozoic rocks of the Ardennes massif (de Wit, et al., 2007), which withstand erosion comparably well. These steep valleys may lead to a very dynamic hydrological regime in some tributaries of the Meuse river, which may lead to rapid changes in the water table and associated flooding in the valleys (de Wit, et al., 2007; Kitsikoudis, et al., 2020). In contrast, the upstream part located in France is located in slightly hilly area, while the dutch part of the river is characterized by wide floodplains located in the lowlands.

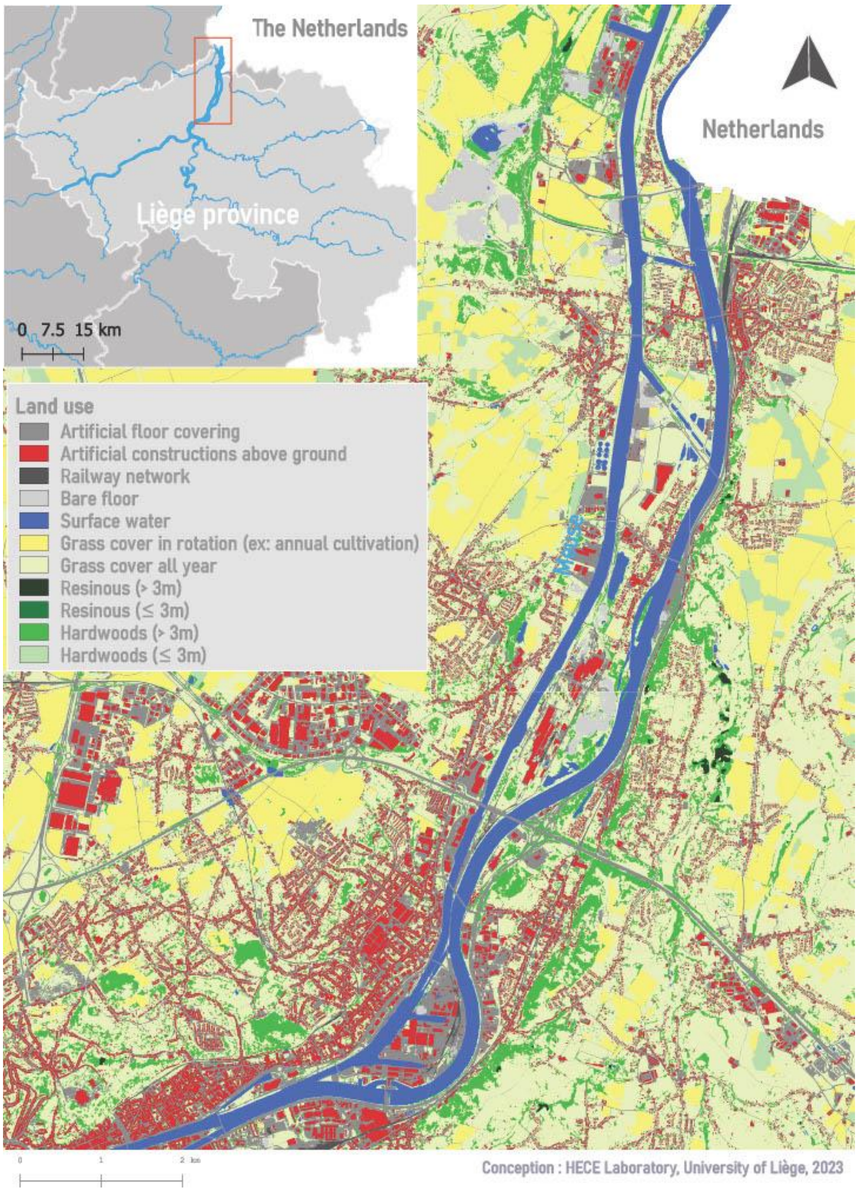

Figure 36: Land use and soil covering in the area of Use Case C

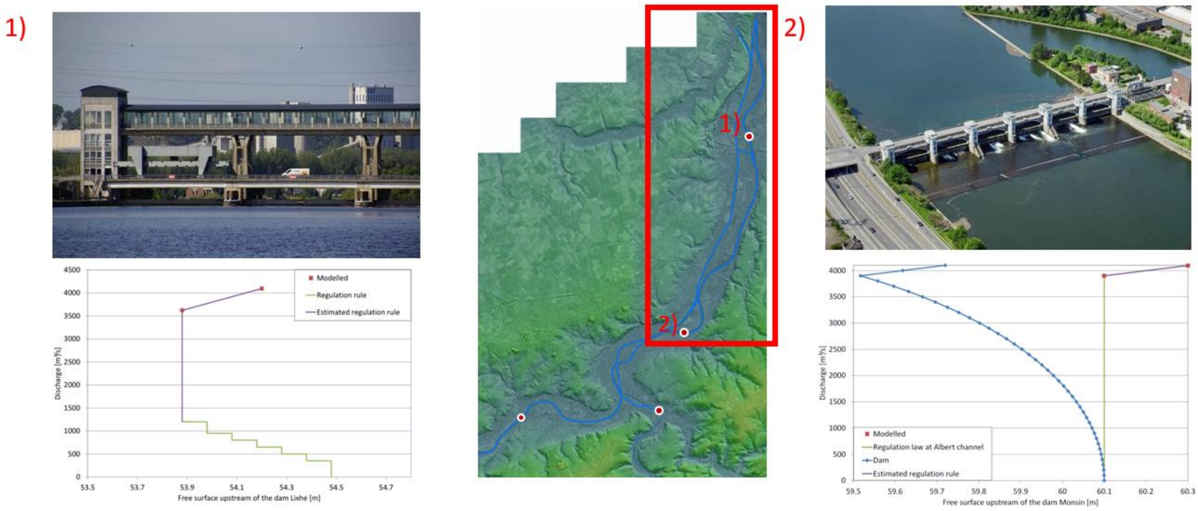

Figure 37: Overview of the study area including the area of focus (red reactangle), and the four dams present in the region (red dots). The numbers 1) and 2) denote dams of Lixhe, and Monsin, respectively. Rivers, and canal sections are denoted in blue being located in the plains. Below the pictures of the according dams, there are also the two associated stage-discharge curves and corresponding regulation laws

Mean annual precipitation in the catchment area ranges between 750 mm at lower altitudes and 1200 mm in the Ardennes massif (Kitsikoudis, et al., 2020). Typical discharges of river Meuse in Liège range between 200 and 300 m^3/s. The high-flow discharge may reach values of the order of 3000 m^3/s, like during the floods of winter 1993. For the devastating flood events observed in July 2021, the discharge in Liège was even higher than the formerly observed 3000 m^3/s. During low-flow periods, the discharge in Liège can drop to 20 m^3/s, as typically observed in late summer (Kitsikoudis, et al., 2020). This leads to a critical situation for shipping, use of cooling water by industry and the industrial sector, as well as for drinking water production downstream of Liège (Flanders and the Netherlands).

7 Conclusions

This report is one of the three Deliverables of WP2 and is related to Tasks T2.1 "End-user needs and good practices analysis of adaptation and mitigation measures" and T2.2 "Specification of system requirements, Use Cases, Scenarios Definition and KPIs". In this report, the normative literature related to technical, regulatory and financial aspects that shall be considered for the development of the PLOTO integrated system, was initially presented. Moreover, the end-users' needs (as identified through the specified methodology), were described. Several interesting findings, related to the IWWs operational difficulties, weather and climate change impacts, as well as to the information system and service development, were identified through the literature review, interviews and questionnaires conducted and presented. In addition, the detailed specification of PLOTO end-users' requirements were analysed and the PLOTO platform's modules were described. Further to the aforementioned, initial information (assets taxonomy, areas' description, operations executed and stakeholders' involved), related to the three PLOTO use cases and scenarios (that will be used to validate the platform in WP7) were presented. As the project evolves and information collected becomes more mature, it is important to mention that in the second version of this report (D2.2 Definition of the Requirements, Use Cases and System Specifications final version, M10), the requirements list might get updated; PLOTO modules will be further described and; use cases and scenario will be further explored.

8 References

Andritsos, F. (2016). *eIWT: Electronic tool for Inland Waterways Transport: Requirements.* Luxembourg: Publications Office of the European Union. doi:10.2788/19691

Bakhshian, A., & Kachlami, K. M. (2019). Inland Waterways Logistics - Operational Requirements & Vessels' Characteristics.

Cavalcante de Barros, B. R., Bulhões de Carvalho, E., & Pinho Brasil, A. C. (2022). Inland waterway transport and the 2030 agenda: Taxonomy of sustainability issues. *Cleaner Engineering and Technology, 8*, 100462. doi:10.1016/j.clet.2022.100462

Christodoulou, A., & Demirel, H. (2018). *Impacts of climate change on transport: A focus on airports, seaports and inland waterways.* Luxembourg: Publications Office of the European Union. doi:10.2760/378464

Christodoulou, A., Christidis, P., & Bisselink, B. (2020). Forecasting the impacts of climate change on inland waterways. *Transportation Research Part D: Transport and Environment, 82*, 102159. doi:10.1016/j.trd.2019.10.012

Cristea and Partners Law office. (n.d.). *Maritime Law in Romania.* Retrieved November 3., 2022., from https://www.cristealaw.ro

de Wit, M., van den Hurk, B., Warmerdam, P., T. P., Roulin, E., & van Deursen, W. (2007). Impact of climate change on low-flows in the river Meuse. *Climatic Change, 82*, 351-372. doi:doi.org/10.1007/s10584-006-9195-2

Desquesnes, G., Nouasse, H., Lozenguez, G., Doniec, A., & Duviella, E. (2016). A Global Approach For Investigating Resilience In Inland Navigation Network Dealing With Climate Change Context. *Procedia Engineering, 154*, 718-725. doi:10.1016/j.proeng.2016.07.574

Erdősi, F. (2007). Van-e jövője a belvízi közlekedésnek Kelet-Európában? A technológiai, gazdasági, környezeti kihívások és a lehetséges válaszok (In Hungarian). *Tér és Társadalom, 21*(4), 39-56. doi:10.17649/TET.21.4.1138

European Commission. (2022, 01 01). *Inland Waterways*. Retrieved 01 18, 2023, from Inland Waterways: https://transport.ec.europa.eu/transport-modes/inland-waterways_en

European Commission. (2022, 12 01). *INSPIRE Knowledge Base*. Retrieved from INSPIRE Knowledge Base: https://inspire.ec.europa.eu/

Eurostat. (2022, January). *Reference Manual on Inland Waterways Transport Statistics.* Retrieved October 3, 2022, from https://ec.europa.eu/eurostat/cache/metadata/Annexes/iww_esms_an2.pdf

Haiduc, A., Nicoara, S., & Neagu, O. (2022). The Evolution of Inland Navigable Waterways and Maritime Ports. *Ovidius University Annals: Economic Sciences Series, 22*(1), 248-257.

Hosseininasab, A. (2015). Regularisation and reliability assessment of data in survey analysis. *International Journal of Data Analysis Techniques and Strategies, 7*(3), 284-300. doi:10.1504/IJDATS.2015.071368

Hungarian Parliament. (2000). Act XLII. on waterborne transport (In Hungarian). Retrieved November 7, 2022, from https://net.jogtar.hu/jogszabaly?docid=a0000042.tv

ICPDR IKSD. (2009, 01 29-30). *BALCU: ISPA 2: DANUBE RIVER BETWEEN IRON GATE II (RKM 863) AND CALARASI (RKM 375).* Retrieved from http://www.icpdr.org/main/resources/balcu-ispa-2-danube-river-between-iron-gate-ii-rkm-863-and-calarasi-rkm-375

Inland waterways — river information services (RIS). (2020). Retrieved October 21, 2022, from EUR-Lex: https://eur-lex.europa.eu/EN/legal-content/summary/inland-waterways-river-information-services-ris.html

ISO. (2018). *ISO/IEC/IEEE 29148:2018: Systems and software engineering — Life cycle processes — Requirements engineering.* Retrieved 10 01, 2022, from https://www.iso.org/standard/72089.html

James, K. J., Shenoy, V. V., Bhasi, M., & Nandakumar, C. G. (2019). Automated ICT Systems in Inland Waterways by Developing a Multiflow River Information Services System. *International Journal of Advanced Research in Engineering and Technology, 10*(2), 389-402.

Khan, S., Dulloo, A., & Verma, M. (2014). Systematic Review of Requirement Elicitation Techniques. *International Journal of Information and Computation Technology, 4*(2).

Kitsikoudis, V., Becker, B. P., Huismans, V., Archambeau, P., Erpicum, S., Pirotton, M., & Dewals, B. (2020). Discrepancies in Flood Modelling Approaches in Transboundary River Systems: Legacy of the Past or Well-grounded choices?. *Water Resources Management, 34*, 3465-3478. doi:doi.org/10.1007/s11269-020-02621-5

Macharis, C., & Pekin, E. (2009). Assessing policy measures for the stimulation of intermodal transport: a GIS-based policy analysis. *Journal of Transport Geography, 17*(6), 500-508. doi:10.1016/j.jtrangeo.2008.10.004

Mihic, S., Golusin, M., & Mihajlovic, M. (2011). Policy and promotion of sustainable inland waterway transport in Europe – Danube River. *Renewable and Sustainable Energy Reviews, 15*(4), 1801-1809. doi:10.1016/j.rser.2010.11.033

Ministry of National Development. (2011). *57/2011. (XI. 22.): Decree on water transport regulation.* Retrieved from https://net.jogtar.hu/jogszabaly?docid=A1100057.NFM&searchUrl=%2Fgyorskereso%3Fkeyword%3D57%2F2011%2520NFM%2520rendelet

Ministry of National Development. (2011). *77/2011. (XII. 21.): Decree on detailed regulations of investigation on accidents and events in water transport.* Retrieved from https://net.jogtar.hu/jogszabaly?docid=A1100077.NFM&searchUrl=%2Fgyorskereso%3Fkeyword%3D9%2F2006.%2520%28II.%252027.%29%2520GKM%2520rendelet

Némethy, S. A., Ternell, A., Bornmalm, L., Lagerqvist, B., & Szemethy, L. (2022). Environmental Viability Analysis of Connected European Inland–Marine Waterways and Their Services in View of Climate Change. *Atmosphere, 13*(6), 951. doi:10.3390/atmos13060951

Nemoto, T., & Beglar, D. (2014). Developing Likert-scale questionnaires. In N. Sonda, & A. Krause (Ed.). *JALT2013 Conference Proceedings.* Tokyo: JALT.

Notices to skippers. (n.d.). Retrieved November 16, 2022, from Danube Fis Portal: https://www.danubeportal.com/hu/noticesToSkippers

Nur Pradana, B. W., Abdul Fattah, M. T., Rachmat Hidayat, R. D., Triyasa, D. H., & Yuliantini. (2020). Analysis Of The Potential For Cbl Inland Waterways As An Alternative Transport Logistics Using AHP. *Journal of Physics: Conference Series, 1573*, 012033. doi:10.1088/1742-6596/1573/1/012033

Nzengu, W., Faivre, J., Pauwelyn, A.-S., Bolbot, V., Lien Wennersberg, L. A., & Theotokatos, G. (2021). Regulatory framework analysis for the unmanned inland waterway vessel. *WMU Journal of Maritime Affairs, 20*, 357-376. doi:10.1007/s13437-021-00237-z

PIANC. (2020). *PIANC REPORT N° 178 - CLIMATE CHANGE ADAPTATION PLANNING FOR PORTS AND INLAND WATERWAYS.* PIANC.

Platform for multimodality and logistics in inland ports. (2015, July). *Recommendations by stakeholders of inland ports in order to reduce barriers and to benefit.* Retrieved September 27, 2022, from https://transport.ec.europa.eu/system/files/2016-09/2015-07-logistics-inland-ports-platform-long-position-paper.pdf

Plotnikova, E., Vienažindienė, M., & Slavinskas, S. (2022). Development of Inland Waterway Transport as a Key to Ensure Sustainability: A Case Study of Lithuania. *Sustainability, 14*(17), 10532. doi:10.3390/su141710532

Priváczki-Juhászné Hajdu, Z. (2019). Magyarország határvízi egyezményei a belvízvédekezés tükrében (In Hungarian). *Hadtudományi Szemle, 12*(3), 177-199. doi:10.32563/hsz.2019.3.11

Renardy, S., Takriet, A., Benitez, J. P., Dierckx, A., Baeyens, R., Coeck, J., & Ovidio, M. (2021). Trying to choose the less bad route: Individual migratory behaviour of Atlantic salmon smolts (Salmo salar L.) approaching a bifurcation between a hydropower station and a navigation canal. *Ecological Engineering*, 169. doi:106304

Rodrigue, J.-P. (2020). *The Geography of Transport Systems.* Retrieved from https://transportgeography.org/contents/chapter5/maritime-transportation/types-maritime-cargo/

Romanian Parliament. (2002). Law No. 528 Of 17 July 2002. *Approving Ordinance No. 22/1999 Concerning The Management Of Ports And Port Services*. Retrieved November 3, 2022, from https://www.global-regulation.com/translation/romania/3073420/law-no.-528-of-17-july-2002-approving-ordinance-no.-22-1999-concerning-the-management-of-ports-and-port-services.html

Roy, A., Tavana, M., Banerjee, S., & Di Caprio, D. (2016). A secured context-aware tourism recommender system using artificial bee colony and simulated annealing. *International Journal of Applied Management Science, 8*(2), 93-113. doi:10.1504/IJAMS.2016.077014

Rules for promoting inland waterway transport in the EU. (2020). Retrieved October 21, 2022, from EUR-Lex: https://eur-lex.europa.eu/EN/legal-content/summary/rules-for-promoting-inland-waterway-transport-in-the-eu.html

Safe and efficient river transport: river information services. (2016). Retrieved October 21, 2022, from EUR-Lex: https://eur-lex.europa.eu/EN/legal-content/summary/safe-and-efficient-river-transport-river-information-services.html

Sárközi, S. (2010). Suggestions for Supplying Meteorological Information to Inland Waterways., *European Inland Waterway Navigation Conference.* Baja.

Scholten, A., & Rothstein, B. (2016). *Navigation on the Danube -Limitations by low water levels and their impacts.* Luxembourg: Publications Office of the European Union.

Schweighofer, J. (2014). The impact of extreme weather and climate change on inland waterway transport. *Natural Hazards, 72*, 23-40. doi:10.1007/s11069-012-0541-6

Shahjahan, M., & Chowdhury, M. M. (2018). Impact of Climate Change on Safe Navigation in Inland Waterways-Bangladesh Perspective. *Bangladesh Maritime Journal, 2*(1), 20-30.

Specht, P., Bamler, J.-N., Jović, M., & Meyer-Larsen, N. (2022). Digital Information Services Needed for a Sustainable Inland Waterway Transportation Business. *Sustainability, 14*(11), 6392. doi:10.3390/su14116392

SPW Mobilité et Infrastructures. (2019). *Stratégie régionale de mobilité. Volet 1 - Mobilité des personnes (In French).* Retrieved January 10, 2023, from https://mobilite.wallonie.be/files/eDocsMobilite/politiques%20de%20mobilit%c3%a9/SRM_PERSONNES_2019.pdf

SPW Mobilité et Infrastructures. (2020). *Stratégie régionale de mobilité. Volet Marchandises (In French).* Retrieved January 10, 2023, from https://mobilite.wallonie.be/files/politiques-mobilite/SRM-marchandises-2020.pdf

Ubbels, B., Quispel, M., Bruinsma, F., & Holtmann, B. (2012). *Deliverable 2.2.1 - Overview of Adaptation Strategies (Final Version).* Brussels: European Commission Directorate-General for Energy and Transport.

UNACADEMY. (2022, 11 03). *Water Transport: Inland Waterways*. Retrieved 01 18, 2023, from Water Transport: Inland Waterways: https://unacademy.com/content/cbse-class-12/study-material/geography/water-transport-inland-waterways/

9 Annex 1 - Transcripts of deep interviews

Dunatár Ltd. – Hungary

András HOLICZA – managing director

Operational difficulties

- When water levels are low, ships cannot be properly loaded, thus not enough goods can be brought in, hence more ships are needed to transport the same amount of goods, but there is no available fleet of this size. In the event of a flood, the ship is unable to moor, resulting in delays in transport, which has a negative impact on the supply chain. The port is affected by lightning, gale-force winds, sleet (icing), and snowfall. In case of negative weather, the next 24 hours are critical.

Impacts of climate change

- The effects of climate change are already being felt in river shipping and in the operation of ports. The incidence and duration of low water levels are increasing. It is most frequent in January. In contrast to low water levels, the incidence and duration of icing are decreasing due to climate change.

Information services

- The port receives information about arriving ships. They can be followed in real-time and information can be collected. However, in many cases, the exact time of arrival is difficult to estimate. It is therefore difficult to plan the work scheduling (loading), which justifies the development of this information service.

MAHART Container Center Ltd. – Hungary

Zoltán FÁBIÁN – managing director

Operational difficulties

- Strong Wind is the main negative factor in the operation of a terminal because terminals can operate safely up to a certain wind speed.
- In heavy rain and cold weather, the container may "freeze" in the boat. This will hinder loading. Such causes are rare or have little effect.
- Dense fog is not a problem and does not hamper navigation in modern sailing.
- The container is such a well-standardised commodity that it can easily be transported by any mode of transport, so if water transport is not available, the customer will either wait until the end of the "dead season" or divert the traffic to another direction, or to another mode of transport.

Impacts of climate change

- Climate change is clearly being felt as more and more droughts occur. This is very noticeable as the drought period is increasing. Which means insufficient water depth on shipping lanes. Traffic is obstructed or impossible to navigate at all. Because of this, traffic is unplanned, so it is delayed or

missed. The existing capacity on the vessel cannot be transferred from one minute to the next, for example by keeping the same price level on a train.
- Icing and flooding are becoming less frequent and less noticeable due to climate change.
- Information services
- Present:
  - Each terminal has a terminal management system. It's quite a complex system, connected to the customers. Usually, data is exchanged electronically.
  - The Automatic Identification System (AIS) contains information on vessels, based on their GPS positions. From this, a lot of data can be retrieved. It is compulsory for individual boaters to log in to this system.
- Future:
  - Expanding access to AIS, providing access to more actors (e.g., terminals) so that they can receive data through this system. This will enable ports to determine the exact position of the vessel and its time of arrival.

Canal and River Trust – United Kingdom

Chris BARNETT – project developer

The canal has been built 200 years ago, so it is very old. Thus, the biggest problem is the fragile infrastructure.

Ice is not a particular problem, as it is not frequent. If the canal is frozen, it will be shut down temporarily, but as the traffic travels for 40 miles per hour, there is no serious problem. Additionally, storms do not cause many problems. The most important issue is rainfall. Once it happens, the boats travel at their own risk, which causes safety issues.

Authorities face a problem with droughting. The system is not operating as it should once it occurs. There is an increasing flood conditions in the past few years, so the managers try to control the water level. Two years ago, an unfortunate incident happened due to the water level, as there was slipping away from the bridge. The institute paid 13 million pounds to secure the problem.

There is only legal boating, personal, and cargo. The size of boats is restricted by the dimensions of the canal. Cargo travel is significant, and the authorities are trying to increase it due to the commercial aspects. But it is restricted by cost-effectiveness.

The volume of freight is relatively small, so it is not cost-effective to introduce information systems programs. At the moment, the authorities depend on old-fashioned systems, as well as printed books for trips and canals.

Hungarian Port Association – Hungary

Béla SZALMA – president

Operational difficulties

- Low water levels make shipping impossible. This causes infrastructure to be inefficient and under-utilised. The amount of goods that can be transported per unit of time per unit of output is reduced. This causes huge losses. But there is a worse effect, namely that many transport companies prefer to transport goods by road or rail rather than by river. Money spent on development becomes money wasted if the river cannot be used.

Impacts of climate change

- Water levels are the most important thing to deal with. In 2018, water levels in Hungary were unacceptably low for more than half of the year. Observations over the past 20 years show that climate change is causing low water levels to occur more frequently and for longer periods.
- Fog is not a problem, with the right radar system navigation can be done properly.
- Icing has occurred in recent years in a few cases and for short periods

Information services

- Future:
  - Development of a port information system.
  - Installation of digital buoys indicating water levels.
  - Appropriate water level forecast.

University of Liége – Belgium

Mario COOLS – professor

Weather impacts on the IWW – in the Belgium context, the low level of water is the main issue. Floods happen but are casual. These two issues limit navigation as they are very extremes. The flood couldn't be mitigated, but an evacuation plan could've been done and improved. Urban planning is necessary to control the impacts and to be better prepared.

During long dry periods, there is no shift to other transport modes. In the last years, transportation was not affected in the main channels. No fog, wind, or heat waves.

Information systems – national meteorological institute provides colour schemes for different weather conditions. They contact specific affected areas (city council) and give instructions for evacuation. However, not all of the cities get information that compromises the results of mitigation/evacuation.

The regional government provides risk evaluation, and an emergency line for contact (SMS communication) but is not available for river floods. A river information system is available but should be better synchronized and optimized. The idea is to optimize the schedule to avoid vessels to be stuck in the canals. For freight transportation, information among local operators, ports, and cargo companies, should be better managed. All stakeholders should be informed, but at the same time securing this information is challenging because some participants are not willing to share due to competitiveness in the market as well as they don't know to who this information is going to be available. Very clear understanding about who is going to use the system and how to use the system (not misuse, policies to be complied with).

Subsidies should be provided by the government in order to make the system available as the users are not willing to pay for the high costs. But of course, subsidies should be provided if benefits society.

Ownership of ports – Belgium ports have a lot of foreign investors, mainly PPP with government and local owners. Private ports are common as well.

Human Shipping Ltd. – Hungary

Béla KOZSDI – managing director

Operational difficulties

- Water and fording depth are critical. A minimum water depth is defined for access to a port. At low water levels, the boat's load capacity is reduced. Low water levels can last up to a year. High water levels require more engine power and more careful mooring because of the higher water velocity. Space gauge has to be taken into account, for example when passing under bridges. High water level is rare these days.
- There are not so many windy periods (1 month a year in total), but above 40km/h the pushing operation can be problematic. Strong winds also have a negative impact on loading operations.
- Fog occurs mostly in spring. Even with radar on board, mooring is still difficult.
- Icing is very, very rare.

Impacts of climate change

- The increasingly frequent low water levels may be caused by changes in the global climate. Furthermore, the disappearance of icing may also be linked to climate change.

Information services

- Present:
  - Water level and weather information. A few days' forecast gives relatively accurate information on these.
- Future:
  - Water level control is an important aspect. Longer-term traffic forecasts would help operations. Forecasting an exact arrival time would be a breeze.

National Institute for Research and Development of Marine Geology and Geoecology. – Romania

Albert SCRIECIU – researcher

A research vessel is used for monitoring the conditions of the water level. During the last summer periods, drought was present, causing traffic jams and restrictions in the navigation. Sometimes the wind can be strong which stops the navigation, but it happens in wide sections only. High waves are generated which can be dangerous. Days with ice, the Danube is frozen. In the past, ice was broken to guarantee navigability, but it seems that this issue is not often anymore. A proper weather forecast will support the elaboration of measures that can be taken to mitigate the effects of severe weather.

Sediment transport is one of the main issues for the ports. Big dams are causing a sediment imbalance and the river is trying to recover from it, erodating itself. The sediment transport is deposited in some sections/entrances of harbours and navigability is compromised.

Colleagues from the lower Danube are working closely with the meteorological forecast institute to have a proper forecast for planning the measures. But there is a lot to improve. Unfortunately, municipalities decide on some measures without consulting these groups, wasting money because the interventions are not efficient.

An integrated information system is urgent. An interactive map where you can see all the variables, weather forecasts, water level, sediment accumulation, etc. Lower Danube administration and the national agency for harbours maintenance: they work to insure the right conditions for navigation.

There is no willingness to shift from IWW to road/railway due to the increase in costs. They prefer to wait for the improvement of weather conditions. Also, they are not willing to invest in technology or improvement of the vessel's design now. However, I see that it’s necessary to start thinking about it due to the climate change and damage caused to their productivity.

How to increase the shift to IWW: information about how efficient IWW transport is compared to other modes. Dissemination of this information is the key. Also, information is spread and not integrated, so people don’t know where to look or to which to trust.

Ferroport Ltd. – Hungary

László MESTER – managing director

Operational difficulties

- **The Danube's lack of regulation has a serious impact not only on shipping and port traffic but also** on groundwater levels. Transhipment/loading takes place in a covered environment. Only heavy snowfall and wind have an impact on loading. Such weather conditions occur very rarely each year (about 1 day per year).

Information services

- In most cases, vehicle tracking is worthless as the sole source of information. Additional information is also needed, as countless actors influence transport. However, it is not worth paying particular attention to positioning, which cannot provide all the information needed. Using GPS is pointless for the port.
- The dispatcher is responsible for communicating the time of arrival of the vessel to the appropriate parties.
- The railway cannot, and the ship refuses to schedule itself.
- Computer support for the loading process is impossible, as the port is a meeting point for several actors (from different ownership backgrounds)

WWF Central and Eastern Europe - Romania

Ana Maria SEMAN – coordinator

The main problem is the low water levels, specifically, in the lower Danube which is caused by long periods of drought (over one month). The flow becomes below 100 cubic meters per second, which is a serious issue.

Extreme flush floods are caused when there is an increase in frequency, which results in sediment problems. These exist in certain spots in the lower Danube, so they have known locations. Navigation is limited to certain locations. Ports unfortunately are not monitored.

The records of water levels are monitored by the meteorological institute on a national level. The water levels are provided every 6 hours. The monitoring happens on the ground, and it is precise and reliable. There are several rising questions of more often monitoring. The main limiting reason is the capacity as there are not enough employees to go to the field every hour in the river administration. The Data is shared with captains. Recently, the low water level happens as unusual and unpredictable events such as in autumn and spring.

There is a need for more studies in emergency, and what-if situations, specifically if the Danube is stuck. Also, the topic of climate change requires more attention. On the other hand, there is a need for exchange studies on this topic. A discussion does not exist between the several studies that have been conducted here and there. Future steps on what should the water and river administrations do.

Inland Waterways International – Europe

Rudy VAN DER WEEN – advisor

In the last years, floods came suddenly and we need to investigate more this phenomenon as it occurred in different parts of the world. So, we need to learn how to forecast and how to be prepared for that. It's predicted that these events will be more and more often.

Maintenance and infrastructure are the keys to managing disruptions. The amount of water should be drained properly. The floods are more frequent and more severe as well. Therefore, both should be improved and receive investments.

Informational services are not very relevant for us because we focus more on tourism and recreation than freight. All the detailed information is not necessary for us, we can manage it the way it is now. If any issues arise, we contact the government authorities for getting any support.

No port operators in their service.

Low water level affects navigation negatively. Due to the heat wave, plants are growing in the rivers which compromises swimming and bathing, it's quite dangerous to users.

Website and newsletter are the current tools. They could be used to disseminate information about the weather, but currently, this information is not available.

10 Annex 2 - Questionnaire

End-user needs on inland waterways

The aim of this survey is to reveal the main impacts of weather and climate change on inland waterways (IWW), which can be mitigated by information services. The significances of impacts are also going to be revealed. By answering the questions, you contribute to the development of a novel information system supporting inland navigation.

The results of the questionnaire are used in the PLOTO project funded by the Horizon Europe program. For further information you may visit the project's webpage: https://ploto-project.eu/

Responses are anonymous. This survey is likely to take about 12 minutes of your time.

1. **General information**

1.1 What is the main activity type of your company? *(Choose one option.)*

a) infrastructure operator
b) transport and logistics operator
c) customer (sender or receiver of the delivery)
d) other organizations

1.2 Please, specify your activity *(Choose one option.)*

infrastructure operator // if the answer of Q1.1 was (a)

- port and terminal operator
- waterway operator
- waterway-related transport infrastructure (road, railway) operator
- waterway-related transport infrastructure (road, railway) user - land transport company/haulier
- IT company developing and operating IWW-related technology

transport and logistics operator // if the answer of Q1.1 was (b)

- carrying company
- vessel operator (shipping company)
- loading company
- warehousing company

other organizations // if the answer of Q1.1 was (d)

- meteorological company
- authority/govern mental institution
- emergency service provider
- NGOs for shipping (association, cluster)
- NGOs for environmental policies
- research institute
- other

1.3 **Which countries does your service area belong to?** *(You can indicate more than one option.)*

Does your service area cover the following countries?

- Belgium
- Hungary
- Romania
- other(s): …

Please, list additional countries which belongs to your service area

1.4 What are the main inland waterways of your operation?
(List the main rivers, canals, etc. in relevance order.)

In the following questions, consider your experience with inland waterways.

2. Effects

2.1 What is the significance of the following weather effects on your operation?
(Assess the weather effects.)

		0	1	2	3	4	5
		I do not face it/ I do not know	very low	low	medium	high	very high
a	low water level						
b	high water level (flood)						
c	fog						
d	icing (extreme cold)						
e	intense precipitation (thunderstorms, ice rain, snow)						
f	strong wind (storm)						
g	heatwave						

2.2. How frequently do you experience the following weather effects?
(Assess the weather effects.)

		0	1	2	3	4	5
		not occurs	once a week	more than once a month	once a month	once in a season	once a year
a	low water level						
b	high water level (flood)						
c	fog						
d	icing (extreme cold)						
e	intense precipitation (thunderstorms, ice rain, snow)						
f	strong wind (storm)						

g	heatwave						

2.3. How long do you experience the following weather effects?

(Assess the weather effects.)

		1	2	3	4	5
		<1 week	1-2 week	3-4 week	1-3 month	>3 months
a	low water level					
b	high water level (flood)					
c	fog					
d	icing (extreme cold)					
e	intense precipitation (thunderstorms, ice rai)					
f	strong wind (storm)					
g	heatwave					

3 Consequences

3.1 Order the impact areas of weather effects in ascending order according to their relevance to your activity.

- shipment
- loading
- storage

3.2 What consequences were caused on <u>shipment</u> by the weather effects?

(Select the most relevant weather effects contributing significantly to the consequences)

		a	b	c	d	e	f	g
		low water level	*high water level (flood)*	*fog*	*icing (extrem e cold)*	*intense precipi-tation*	*strong wind (storm)*	*heat-wave*
a	delay							
b	blocking the IWWs							
c	vessel damage							
d	reduced capacity utilization of the vessel							
e	higher resource requirement (e.g., energy price, labour-force cost)							
f	spoilage of goods							
g	loss of goods							
h	additional maintenance							

3.3 What consequences were caused on loading by the weather effects?

(Select the most relevant weather effects contributing significantly to the consequences)

		a	b	c	d	e	f	g
		low water level	high water level (flood)	fog	icing (extreme cold)	intense precipi-tation	strong wind (storm)	heatwave
a	blocked cranage							
b	blocked cargo slide							
c	vessel damage							
d	stuck cargo in the vehicle							
e	longer loading time)							
f	loss of goods							

3.4 What consequences were caused on storage by the weather effects?

(Select the most relevant weather effects contributing significantly to the consequences)

		a	b	c	d	e	f	g
		low water level	high water level (flood)	fog	icing (extreme cold)	intense precipi-tation	strong wind (storm)	heatwave
a	cargo eroded							
b	storage facility damaged							
c	impassable depot							
d	electricity supplier (transformer) damaged							
e	underutilization of storage facilities							

4 Available information systems and services

4.1 What kind of channels do you use to alert your organization?

- Radio
- Mobile phone
- Online application

- Other

4.2 List the name of used infocommunication services in each type regarding inland navigation.

(Skip this question if it is irrelevant.)

1. meteorological forecast: …
2. water level information: …
3. water traffic information: …
4. port information: …
5. other: …

4.3 Evaluate the used infocommunication service types according to spatial/local relevance.

(Skip the type if it is irrelevant.)

		1	2	3	4	5
		very low	low	medium	high	very high
a	meteorological forecast					
b	water level information					
c	water traffic information					
d	port information					
e	internet availability					
f	GPS based navigation					

4.4 Evaluate the used infocommunication service types according to timeliness.

(Skip the type if it is irrelevant.)

		1	2	3	4	5
		very low	low	medium	high	very high
a	meteorological forecast					
b	water level information					
c	water traffic information					
d	port information					
e	internet availability					
f	GPS based navigation					

4.5 Evaluate the used infocommunication service types according to accuracy.

(Skip the type if it is irrelevant.)

		1	2	3	4	5
		very low	low	medium	high	very high
a	meteorological forecast					
b	water level information					
c	water traffic information					
d	port information					
e	internet availability					
f	GPS based navigation					

5 Needed/proposed information services

5.1 What decision-making and operational control tasks would need novel information services? List tasks in each type! *(Skip the type if it is irrelevant.)*

a) strategic planning: …
b) tactical planning: …
c) operational control, planning/dispositions: …

5.2 List the needed/proposed information services related to the task types.

(Short interpretation is also welcome. Skip the type if it is irrelevant.)

a) strategic planning: …
b) tactical planning: …
c) operational control, planning/dispositions: …

5.3 What is the importance of the following information services in your operation?

(Assess the information services.)

		0	1	2	3	4	5
		Not relevant	very low	low	medium	high	very high
a	hourly notification about water level						
b	automatic, location-based weather information						
c	automatic, location-based traffic-related information						
d	information about short-term bottlenecks						
e	information about the predicted available capacity of ports, border control stations						
f	visualize the signaling during navigation						
g	information collection and recording by users along waterways (experiences, observations about weather, traffic)						

5.4 **How early forecast about weather effects would support mostly your activity?**
(Indicate the duration in each service type.)

		0	1	2	3	4	5
		Not relevant	before a few hours	before one day	before 3 days	before a week	before a month
a	low water level						
b	high water level (flood)						
c	fog						
d	icing (extreme cold)						
e	intense precipitation (thunderstorms, ice rain, snow)						
f	strong wind (storm)						
g	heatwave						

5.5 What are the communiaction deficiencies related to inland naviagation within your organization, if you have?

5.6 List the activity areas where you prepare and apply troubleshooting/emergency plans!

6 Comments

6.1 Please, add any comments about the current and desired situation on inland waterways, and the related information services

Thank you for your time.

If you have any question, please, do not hesitate to contact us: info@ploto-project.eu

If you are interested in the project, please, visit our webpage: https://ploto-project.eu/