DELIVERABLE 5.1

POLICY GUIDELINES AND LONG TERM DEVELOPMENT PLAN

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1. Introduction

The project ECCONET aims to assess the impacts of climate change on inland waterways transport. Continuous and apparently more notable climate change forms a long-term phenomenon which may have various consequences for precipitation, temperatures, water discharge in rivers and, consequently, on water levels which, in turn, may impact the conditions of navigation on the European inland waterways network. In particular, more frequent and longer lasting low water periods are very likely to increase costs of operations, and therefore transport prices and reduce reliability. Different climate change scenarios were studied in work package 1 (WP1) of ECCONET with their projections on weather conditions in the future. The year 2050 was used as reference year of the study.

Since the consequences of climate change scenarios will influence water levels and therefore fairway conditions of the rivers Rhine and Danube which form together with its tributaries the core of the European waterway network, ECCONET aims to identify and to assess suitable adaptation strategies. Work Package 2 (WP 2) identified a number of adaptation measures addressing the inland waterway fleet with its technology and operations; followed by adaptation measures in the domains of infrastructure; improved procedures for medium and seasonal water level forecast; and finally, in the domain of production and logistics processes by shippers which use inland waterway transportation.

The practical or "engineering" analysis of the technical and operational adaptation measures demonstrated that certain technical measures and coupled convoys are seen as promising approaches on a general level. With regard to operational measures, the upgrade of smaller, less low-water sensitive vessels to the continuous operation mode demonstrated itself as unattractive option, after an initial practical analysis.

In order to test the robustness of the inland waterway transport system to climate changes on the Rhine and the Danube corridors, work package 3 (WP3) focused first on cost effects of adaptation measures. This then served as input to prepare and calibrate the transport model NODUS, construct the reference scenario, assess modal split effects due to climate changes and evaluate technical and adaptation measures with the NODUS model.

WP 3 demonstrated that the possible climate changes from 2005 to 2050 and their impact on the Rhine market, as modelled by two long term dry and wet scenarios, are not likely to be strong enough to trigger any significant shift in modal shares away from inland waterway transportation, but that shifts between ship types within inland waterway transport may occur.

NODUS calculations resulted in a small gain of market share on the Rhine in case of the wet scenario, and a very small loss of market share in case of the dry scenario. For the Danube, NODUS calculations indicated a rather low sensitivity for either scenario. The analysis of the most suitable vessel to carry the cargo in the mentioned scenarios showed that a drier scenario would justify maintaining more small vessels in operation, even with the planned improvements in waterway infrastructure.

Finally, the cost effectiveness of selected adaptation measures was assessed in WP4. Aprons generally lead to a surplus of cost decrease over discounted investment costs. Light-weight structures only have marginal positive effects for GMS 135 type under optimistic climate scenarios, which implies that ship weight is already near its optimal level. Flat hulls for pushed boats are not considered as cost effective.

This deliverable 5.1 focuses on policy recommendations and a long-term development plan designed to assist in implementing the recommended policy, based on the results and findings of the previous work packages briefly described in previous paragraphs. This report is organised in the following way: This first chapter provided a brief recap of the work done in ECCONET; chapter 2 defines the policy recommendations; chapter 3 gives a wider array of suggestions for an inland waterway transport development plan; while at the end, chapter 4 contains the summary and conclusions.

2. Policy recommendations

2.1 Introduction

Even though the results of ECCONET did not reveal alarming impacts of climate change on inland waterway transport in the first half of the 21st century, the sector will certainly be faced with altered navigational conditions in the second half of the 21st century, most notably with prolonged low water periods. In those periods, cost efficiency of the inland waterway transportation sector will be reduced due to lower payloads being transported; at the same time also more frequent high water events with complete traffic bans are to be expected in the 2nd half of the century. In this view, the sector will have to implement effective adaptation policies in order to maintain the competitive position of inland waterway transport and to continue attracting cargo towards a positive modal shift. Moreover, without serious adaptation policies, the IWT sector may face losses of its market share due to losses in cost effectiveness and in reliability of transport operations in a long-term perspective. Therefore, this report attempts to identify a set of practical and realistic policy actions which may assist the inland waterways transportation sector to successfully adapt to tangible impacts of climate changes in the future.

The spirit of the suggested policy actions are the following policy objectives:

- Preservation of inland waterway transport as an efficient, robust and climate friendly transport mode under all navigational conditions.
- Maintaining and increasing the modal share of inland waterway transport in the European transport market
- Adaptation of the inland waterway transport fleet to the expected navigational conditions
- Adaptation of the waterway infrastructure to the expected navigational conditions.
- Adaptation of ports into efficient logistics hubs capable of handling modernized fleet.

For the purpose of reaching these objectives, a set of policy actions was drafted in ECCONET, and is summarized in the following section.

Despite of the initial intention of ECCONET to contribute to PLATINA (Platform for the implementation of NAIADES) with targeted policy recommendations, it has to be noted that at the time of writing of this report, the PLATINA project was already finished, and its follow up project was about to be started. Therefore, the policy recommendations drafted in this chapter shall not only provide a standalone set of policy recommendations for adaptation of the inland waterway transportations sector to the predicted climate change impacts, but shall also feed into the work of PLATINA II.

2.2 Policy actions

ECCONET proposes the following set of policy actions in order to meet above defined policy objectives:

- Policy action 1: Continuous observation of climate change impacts on IWT and their quantification
- Policy action 2: Support the adaptation and modernization of IWT fleet
- Policy action 3: Development of adaptation measures for infrastructure and improved hydrological predictions
- Policy action 4: Development of a state-of-the-art waterway management system through stronger cooperation between waterway administrations”
- Policy action 5: Permanent and pro-active cooperation of river commissions
- Policy action 6: Preparation of ports for efficient handling of adapted/modernized vessels

Having in mind the transnational scope of the predicted climate change effects on the European inland waterway transport system, all proposed policy actions must be defined and implemented in close co-operation of the States adjoining the rivers. River commissions as well as the relevant industry stakeholders have to be involved and should strongly be supported by the European Commission services for Pan European-wide co-ordination and EU funding.

It also has to be mentioned that some of these policy actions require changes and improvements in national and supranational/European legislation for the purpose of fostering a full scale policy implementation. Due to the Pan European dimension, the policy implementation should be based on a long-term development plan. Core elements of this plan and its necessary environment are detailed in the following chapter.

3. Long-term development plan

The proposed long-term development plan will be based on the following **vision for the development of inland waterway transport** in view of expected impacts of climate change:

"Inland Waterway Transport in the middle of the 21st century and beyond remains a highly reliable, cost efficient and the most climate friendly mode of transport. It holds the leading position in technological and operational innovations both focussing on adaptability to climate change effects and reduction of its own impacts on climate change and environment."

In order to transform the above vision into achievable and measurable results, the responsible bodies will have to apply dedicated measures for each policy action as described above. The following paragraphs provide suggestions and basic elements for such a long-term development plan aimed at the implementation of an adaptation policy.

3.1 Continuous observation of climate change impacts on IWT and their quantification

This policy action is suggested to consist of the following implementation measures:

- Elaboration and implementation of follow-up projects and studies which deliver further and more comprehensive results on the impacts of climate change, based on updated and more detailed future water discharge models of the major European navigable rivers;
- Design of an integrated system and comprehensive processes respectively for measuring climate change impacts on IWT;
- Set up of key performance indicators in IWT and quantification of climate change impacts on them.

Investigations in the framework of ECCONET clearly demonstrate the need for further and proficient research on the impacts of climate changes on IWT. This especially refers to the **Danube**. Whereas the discharge models for the Rhine in relation with the profound research study KLIWAS are considered by most experts as a robust basis for projections, the input models used for the Danube lack in a similar level of detail. The applicability of conclusions by analogy between the two riverine systems is therefore tainted with insecurity. The differences in hydrological characteristics, the impact of a more continental climate, and the consequences of a more rapid melt-down of Alpine glaciers could possibly suggest a more restricted application of analogy as it was applied in the existing studies.

With regard to the necessary long-term research needs, the following research areas can be identified:

- *Improvements in disclosing data and information needs*: Transportation practitioners need to be able to identify the types of climate data and model projections that will be relevant to transportation decisions: What information could encourage a public or private transportation agency to change a transportation investment plan, port/terminal location, or facility design? Determining what climate information is useful includes identifying the appropriate regional scale and timeframe for climate scenarios, as well as the types of climate factors that could result in a revised decision.

- *Identifying most relevant climate information*: climate scientists need to explain to transportation and planning professionals what information is available today that may be relevant and useful to/for transportation decisions.

- *Integrating multiple environmental factors*: climate factors need to be considered as part of a broader set of social and ecological factors which influence managed transport chains. This will require cooperation of climate scientists and geospatial specialists with transportation planners to integrate climate information into maps and data addressing other environmental factors. Incorporating new types of information – including longer range climate scenario projections – may require the transportation community to adopt new approaches to logistics planning and execution processes.

- *Incorporating uncertainty*: an additional challenge is learning how to incorporate uncertainty in transportation decisions – how to assess risk and vulnerability of the transportation system and individual facilities, given a range of potential future climate conditions.

Finally, very little if any information exists that addresses the possible consequences of climate change for transportation demand.

As a logical continuation of the efforts made in quantifying climate change impacts in WP3 and WP4 of ECCONET, the quantification of climate change impacts on determined transportation sensitivities should be subject of further studies. An overview on these interrelations is given in Figure 1.

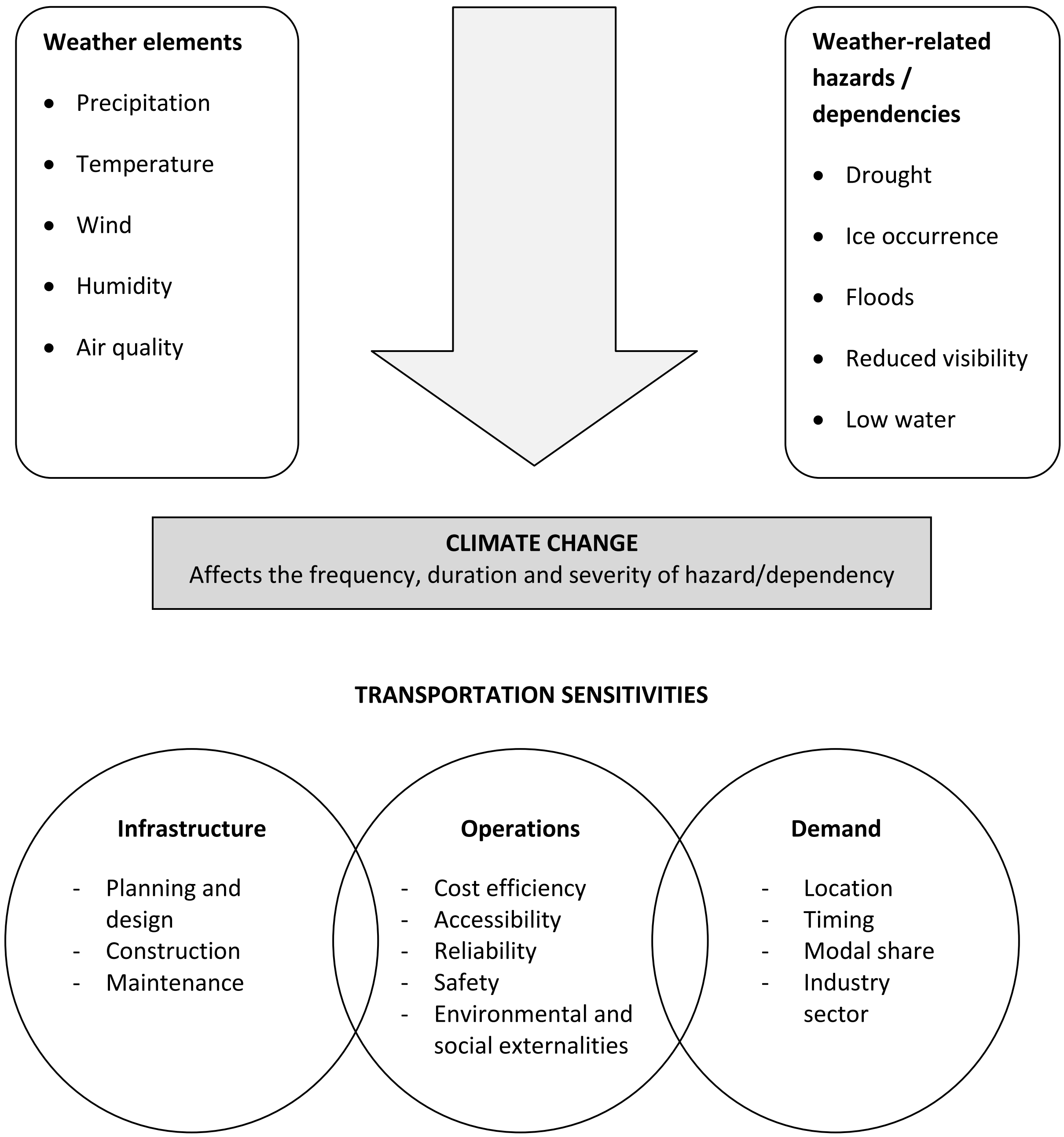

Figure 1: Interrelations between climate change and transportation sensitivities

Another challenge for the quantification of climate change impacts consists in the definition of performance indicators for inland waterways transportation and in the selection mechanism for those parameters which enable the quantification of the particular impact. In general, performance indicators provide an effective and practically approved method to support decision making processes by working out the causes and effects that directly and indirectly influence the achievement of goals and corresponding results. The open task is to develop applicable performance indicators in the different areas of inland navigation with regard to climate change impacts and furthermore improved competitiveness of waterborne transport. As initial input for a possible study on performance indicators to quantify climate change impacts, PIANC's report "Performance Indicators for Inland Waterways Transport – User Guideline" published in 2010 might be used. Some future study should investigate the possibilities of designing a model which allows the quantification of interrelations between climate change impacts and determined performance parameters. Quantification of such interdependencies should provide measures that enable timely feedback for users and ensure adequate action on time.

3.2 Support to the adaptation and modernization of IWT fleet

Public support to the adaptation and modernization of various segments of inland waterways transportation is most commonly materialized through:

- Research and innovation activities as part of national and European RTD activities;
- Adequate legislation and creation of an efficient and harmonized regulatory framework;
- State-aid schemes which stimulate the transition to innovative, adapted, efficient and more environmentally friendly vessels.

The research activities carried out as part of national and European research and innovation programs will have to address the following topics in order to better deal with changing water level conditions:

- ship structural materials, e.g. light weight structures
- improved hull configurations and propulsion
- assistance systems for energy- and cost-efficient sailing with ships adapted to altered navigational conditions due to negative effects of climate changes
- Education- and training standards, facilities and –classes for energy-efficient navigation in various water level conditions

Continuous research and investment processes are important in order to provide the market with efficient, clean and safe technical solutions, practices and approaches. This is also needed in order to retain a competitive advantage in terms of greenhouse gases emissions and safety levels.

Specific funding opportunities for research and innovation in IWT technologies aimed at adapting to the climate change effects will have to be provided in the EU research and innovation programs like Horizon 2020 and their deployment in the Connecting Europe Facility (CEF) as well as on a transnational level in the framework of European territorial cooperation.

The situation with economic and legislative incentives to modernise is somewhat different, and varies from country to country. For the Rhine area it seems that on short term no big changes are needed to the vessel design due to the uncertainties on the actual impact of climate change towards the horizon

2050[1]. However new vessels have a long lifetime. Therefore actions should focus on addressing the design of new vessels concepts that enter the market. Therefore flexible ship configurations are needed and the focus shall be on 'no regret' ship designs such as attention to coupled convoys. Possible burdens of additional investment cost for new vessels to anticipate on altered navigational conditions on longer term cannot be placed on the vessel owners alone. This is particularly the case because the low capability to invest in modern vessel equipment is a consequence of the low profit margins, caused by current overcapacity in the Rhine market and an extremely tough competition among the barge operators. Whereas the Western European system of small business owners (Partikuliere, with just one or a few barges) limits investment capabilities, the poor infrastructure status in the east on the Danube deprives the owners of profits needed for re-investment.

Moreover the longer term assessment of climate change makes clear that there is a market for smaller vessels. However currently the small vessels are relatively old and could profit from modernisation. In order to ensure a sufficient shareof smaller vessels in the future innovation is needed to be able to compete with older vessels that have low capital cost.

The entire system of inland waterway transportation is of crucial importance for a sustainable economic development in Europe and therefore deserves the full attention of both national and supranational authorities, who will have to come up with acceptable economic and legislative incentives as well as a harmonized and transparent regulatory framework to enable easier renovation and adaptation of IWT fleet in the medium and long term.

3.3 Development of adaptation measures for infrastructure and hydrological predictions

The quality of infrastructure directly affects cost efficiency and service quality of inland waterway transportation. In particular the conditions of the fairway and existing bottlenecks directly influence the degree of vessel utilisation, fuel consumption, load factors and the quality of service such as the delivery speed and time reliability. Therefore, waterway maintenance, and especially the maintenance of the fairway's guaranteed or recommended depth, is of crucial economic importance. Low water situations have a large impact on the required energy to move the vessel, therefore also from the viewpoint of external costs of inland waterway transport it is beneficial to have sufficient waterway depth.

Having in mind that interventions on waterways involve many sectors (transportation, agriculture, water supply, power generation, tourism, etc.), ECCONET believes that an integrated approach towards the development of infrastructure adaptation measures requires an adequate funding by the public waterway administrations and has to address the following areas:

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[1] Beyond the scope of ECCONET however, there is a strong neccesity to modernize the existing IWT-fleet in terms of new power sysem configurations and retrofiting techniques for existing engines as contribution to climate change mitigation.

- Development of innovative methods for the improvement of river monitoring (shear stress, sediment transport, morphodynamics etc.)
- Development and programming of numerical models (3D hydrodynamics, sediment transport and habitat modelling)
- Development and optimisation of river engineering works in order to improve navigable conditions in line with the minimisation of river bed degradation, the optimisation of flood protection and maximisation of improvements in environmental conditions

Among the investigated adaption options for reducing the negative impact of climate change on inland waterway transportation, an improved infrastructure management carried out by the waterway administrations must be considered as most relevant and essential for a successful adaption strategy. Despite the relatively modest overall impact of climate change at short and mid-term perspective, the high impact of low water situations on the efficiency and thus on the competitiveness of inland waterway transportation requires changes in short-term, mid-term and long-term maintenance and engineering strategies. These strategies should include different sets of measures in order to provide adequate responses to different climate change impact scenarios:

- Short-term adaptation measures mainly address continuous waterway maintenance activities and strategy: In case of changing water discharge patterns (e.g. altered seasonality of low water periods) the fairway maintenance cycle (surveying, dredging and provision of information) shall be accordingly adapted on the time axis. This includes an optimal timing of the necessary dredging works during the year which takes into account changing temporal distributions of the river's water discharge. Improved utilisation of the fairway can be achieved by provision and usage of up-to-date comprehensive information on the fairway conditions as well as implementation of concepts like “fairway-in-the-fairway”. For this purpose waterway administrations need to have sufficient and modern surveying equipment (i.e. surveying vessels and software for data processing and analysing). The purchase of such specialized equipment should be co-funded with the help of European funding schemes (e.g. TEN-T and Structural Funds).
- Another important climate change adaptation measure for waterway administrations should be the continuous and differentiated monitoring and analysis of the development of the river’s water discharge regime. The currently used statistical water level reference indicators (LNWL – Low Navigable Water Level, MWL – Mean Water Level, HNWL – Highest Navigable Water Level) represent statistical values based on a long-term (30 years) time series. In order to better evaluate and recognise potential climate change effects shorter statistical time series should be additionally taken into account (e.g. 10 years) which would allow better to monitor potential (mid-term) alterations of the water discharge regime. Furthermore waterway administrations could develop additional indicators for alterations in the water discharge regime. Such indicators could include long-term seasonal analysis of the water discharge regime as well as a dynamic analysis of low water conditions: e.g. the lowest water levels within a series of consecutive days (e.g. 3, 5, 7, 10, 21 days).

- Medium and long-term measures include structural modifications of river engineering works as an adequate response to more severe climatic changes. The adaptation of the waterway infrastructure via river engineering works (e.g. groynes and training walls) should be undertaken on the basis of a continuous monitoring of the effectiveness of these elements, whereby the monitoring intervals have to be adjusted to the changes in the discharge regime as well as the river morphology (as the frequency of changes increases, monitoring intervals should become shorter). This means that the life-time of river engineering works will most probably not be up to 100 years (as calculated in the past), but significantly shorter. In case of such a changing framework, these river engineering works will have to be adapted accordingly e.g. by lengthening/shortening and/or heightening/lowering of such structural elements. In order to respond these new requirements waterway administrations need to foresee respective budgets. These budgets must be planned and allocated in addition to the conventional budget for maintenance measures like surveying and dredging.

Concerning the improvement of hydrological predictions, ECCONET recommends the development of integrated prediction services which enable the users to retrieve more accurate forecasts and which provides support to better manage risks. These services should incorporate applicable data from the historical records, current observations, forecast point descriptions, maps, geographic information and other data which would enhance users' understanding of the probability and the impact of potential and forecasted hydrologic events, most notably water levels. Key features of these services shall include the following aspects:

- Coverage of full spectrum of hydrologic events, such as rising floods, water level observations and predictions and droughts over regional areas
- Expanded use in water resources applications such as water supply and environmental impact mitigation
- Display of information in graphical and numerical formats which maximize usefulness to users from different sectors
- Inclusion of probability information on the possible range of future flow conditions
- Consistency of format and information content of core products on global level
- Use of geographic information systems (GIS) in the graphical display of forecasted information
- Internet-based and wireless dissemination of information to broaden access to information and to facilitate efficient decision making
- Inclusion of relevant information into RIS where applicable and useful

These features will support the following achievements:

- Improvement in very high-resolution dynamical models used for numerical weather prediction by extension to longer time-scales
- Improvement of empirical (statistical) models and methods

- Improvement of forecasting by using different sources of predictability, including the soil initialization methods
- Inclusion of comprehensive information about the stratosphere
- Successful coupling of meteorology and hydrology through combination of short, medium and long-term forecasts and the cooperation between the national and international institutes

3.4 Development of a state-of-the-art waterway management system through stronger cooperation between waterway administrations

The cooperation between national waterway administrations has a long tradition in Western Europe in particular in the framework of the Central Commission for Navigation on the Rhine (CCNR). In the Danube region co-operation gained in importance with the enlargement process of the European Union. A good example of a successful cooperation is the project "Network of Danube Waterway Administrations" (NEWADA) and its follow-up project NEWADA DUO executed in the South-East-European Transnational Cooperation Programme (SEE). NEWADA led to an intensified co-operation of all waterway administrations along the Danube in the domains of hydrology, hydrography, waterway maintenance, information provision as well as business strategies. The existing cooperations provide very positive results and should be continued on a wider, Pan-European level and adequately stimulated through dedicated public funding schemes.

With regard to climate change adaption, a cooperation of waterway administrations has the focus to develop a state-of-the-art waterway management system as well as further standardisation and extension of waterway related information. Such information shall include the following segments:

- Water level information including forecasts
- Actual information on critical / shallow sections
- Accurate information on bridges, ports, locks
- Identification of and access to responsible authorities

Through cooperation between the European waterway administrations, this information can be bundled, providing a selectable array of standardised and detailed information in a user-friendly application as part of River Information Services (RIS). This is also referred to as an application of the "smart waterways" concept.

The deepened exchange of knowledge and expertise gained in such a co-operation will also serve strategic aims like:

- Increase of awareness of different stakeholders on climate change impacts on IWT and related industries
- Establishment of a joint "task force" for the purposes of rapid reaction in cases of severe disturbances in navigation caused by hydrological/meteorological phenomena
- Communicating the need of secured long-term finance for infrastructure development and maintenance of the entire waterway network

- Operation of an integrated smart network of waterways across Europe
- Contributions to a comprehensive European research strategy and agenda for river engineering and waterway management as part of an European inland navigation R&D program (in the framework of Horizon 2020)
- Supporting the creation of a European river engineering and inland waterways transportation science partnership with the aim of establishing dialogue between the scientific community, the industry and policy makers.

3.5 Permanent and pro-active cooperation of river commissions

Although it is a politically sensitive issue, the discussion on the future institutional setting for inland navigation in Europe must come to a concrete output at a mid-term perspective. The magnitude of the economic challenges which the inland navigation sector will have to manage successfully in the future requires a robust and action driven institutional setting which also brings the institutional framework in line again with the achieved status of the integration process of the European Union.

As part of a new and improved institutional setting, a stronger and more detailed cooperation of river commissions should be materialized with the help of a permanent coordinating and monitoring mechanism working on European level. Among the wide array of objectives such a mechanism might have, a certain number also should refer to the adaption and mitigation of negative climate change impacts. Some of those objectives could be:

- Creating a strategy to alleviate the consequences of climate change in river systems
- Supporting international efforts to reduce the climate impact attributable to waterway transportation
- Support to the development of a comprehensive inland waterways transport strategy for the next ten years with the overall target to improve the efficiency, competitiveness and environmental performance of inland waterway transportation in Europe including attention to mitigate impacts on waterlevel conditions due to climate change
- Support to the implementation of the Joint Statement of Environment & Inland Navigation Development by providing technical assistance
- Encouraging the formation of multi-sector clusters and promoting technological innovation for fleet modernisation, fleet operation, port & terminal infrastructure

Though the river commissions are mainly addressed to deploy these objectives, strong support of all member states of the commission is essential.

3.6 Preparation of ports for efficient handling of adapted and modernized vessels

Inland ports often have been neglected in national transport policies and infrastructure development plans despite their important role as multimodal nodes and centres for regional economic development. Nevertheless, the competitiveness of inland waterways transportation and multimodal logistics chains heavily depends on the efficiency of port operations.

There are approximately 1.500 inland waterways ports on the European continent. More than half of those ports are located along the main corridors of the TEN-T inland waterways network. All of them have an important regional and local role in the development of clusters of economic centres of industry and logistics, as well as in the development of job creation in the affected regions. Furthermore, they are inevitable and important links in transport chains and contribute to the added value of logistics.

Many inland ports are located in the strategic hinterland of the gateway seaports. Inland ports are therefore increasingly serving as back up and feeder for the major European seaports and can be a part of the solution for the congestion in the seaports. Taking into consideration the reality of economic and transport flows, and the possible impacts of climate change resulting in temporaryly reduced performance of IWT it is clear that a sustainable European transport system requires strong co-modality and therefore more focus on inland ports as enabler of cost-effective and reliable logistics chains.

In order to meet the challenges of operation under predicted altered navigational conditions and with modernised and adapted inland vessels, inland ports will have to develop dedicated long-term adaption strategies and plans. Among the related measures there will be the following activities:

- Adaptation of working hours of ports & terminals for handling vessels adapted for continuous operations
- Provision of adequate berths, anchorages and shore equipment to handle larger number of vessels due to increased convoy size
- Infrastructure adjustments/provision of vertical quays in order to accommodate transhipment even under extreme low water conditions
- Improved fairway management in port areas
- Upgrade of transhipment facilities enabling transhipment under extreme low water conditions and providing cost-effective throughput capacity for alternating volumes
- Establishment of improved links to alternative transport modes such as rail corridors in order to guarantee service levels of transport operations in case of problems on the waterways (e.g. extreme high/low water levels)
- Increase storage capacities for increased seasonal logistics buffers and additional value added services for logistics chain modifications
- Provision of adequate fendering systems (for vessels of higher damage sensitive lightweight structures)

Many ports, especially on the Danube, work only in two daily shifts, with total closure on weekends and during the night. Since continuous (24 hrs/day) operation is gaining in importance, inland ports will have to adjust their working hours according to the operational needs of the fleet operators and their customers.

Another important adaptation measure for the inland waterway transport fleet is the increased operation of coupled convoys where the payload can be distributed to several barges and resulting therefore in lower draught. For inland ports this means that the same quantities of cargo will have to be loaded or unloaded from from/in a higher number of vessels. This will require additional time for berthing/de-berthing manoeuvres, anchoring, loading and unloading and other operational activities. Ports will therefore have to increase the capacity of their berths by increasing capacity of loading/unloading equipment and/or by constructing additional berths with new loading/unloading equipment. Additional space for anchoring may also be needed. Furthermore, depending on the layout of the port basins, a smooth and safe entrance/exit of coupled convoys will require additional infrastructure investment or assistance for de-coupled barges with port tugs or port push-boats.

Some ports, especially those located on riverside (non-basin ports) will need infrastructural adjustments of their quays as more frequent and longer lasting low water periods will hinder the access to the quays. In extreme cases, entire berths may end up on dry land due as result of the reduced water levels and resulting into a break in transhipment operations. In less extreme cases, vessels will not be able to approach close enough to the berth in order to be moored or to be effectively loaded or unloaded from the shore. Therefore, depending on the quay foundation, ports will have to undertake either significant dredging off the affected quays and in its approaches, or to reconstruct entire quays in order to overcome these serious deficiencies.

If ports become faced with operations of ships made of lightweight structures, existing fendering systems along the berths may no longer be adequate. For damage-sensitive vessel hulls, pneumatic fenders seem to be very appropriate as they offer a high energy absorption, low reaction force and surface pressure. Low reaction force prevents the hull, quay, jetty and anchor chain from being damaged.

4. Summary and conclusions

ECCONET focusses on the evaluation of the effects of climate change on the network of inland waterways and the operational performance of inland waterway transportation. The results of the study did not indicate a significant immediate effect of notable climate changes, but they provide sufficient evidence that climate change adaption strategies and related measures shall become part of an overall long-term European inland navigation policy. The adaptation needs in particular refer to the year 2050 and beyond when climate change is predicted to change the discharge characteristics of the analysed rivers more significantly.

The expected increase of low water periods is not foreseen to cause a substantial effect on modal shift in both analysed scenarios ("wet" and "dry") **at least until mid of the century** (up to 2050). As a consequence, **inland waterway transport is expected to stay a reliable and cost-effective transport mode**.

For the more distant future (2071-2100) however, the study revealed that the costs of Inland waterway transport will increase more significantly in all analysed areas of the Danube and Rhine waterways due to adverse impacts of climate change. Accordingly, suitable adaptation measures were defined and evaluated according to different criteria. The long-term aspect of waterway infrastructure investment and the unclear impact of human interventions, like increased water storage for irrigation and energy production, not only justify the elaboration of these adaption measures, but also demonstrate the need for further research. It also has to be mentioned that the efforts to reduce global greenhouse gas emissions are lagging significantly behind the political ambitions, thus increasing the level of uncertainty for the future development.

With regard to the impact of climate change on Danube transportation, the underlying input models lack the level of detail of those applied for the Rhine. It therefore cannot be excluded that e.g. the different characteristics in water discharge, the more continental climate of the Danube region and other different natural and anthropogenic factors will have a more significant impact on low water periods as the analogical assumptions to the Rhine imply. The current insufficient status of waterway maintenance and the high number of existing low water bottlenecks presume a higher vulnerability of Danube transportation to additional external strain.

The main task of WP5 was to draft policy recommendations and to design a long-term development plan for the implementation of the recommended policy actions, based on the results of the previous work packages. This development plan will assist in the preparation of the inland waterway transport sector for the forthcoming periods, and enable it to maintain or even upgrade its competitiveness as an environmentally friendly, cost efficient and reliable mode of transport.

The overall conclusion of WP5 is that, although no immediate action to combat the climate change effects seems to be necessary, a targeted policy taking into account the climate change and its effects on the IWT system is advisable. Therefore, all future inland waterways transport strategies, development plans and implementation programs should include the proposed specific activities aimed at the adaptation to the predicted climate change impacts. Further research to monitor the development path of climate change and its impact on European waterways is essential, as well as the reduction or elimination of uncertainty.

The following table provides an overview on the recommended long term development plan with its policy actions as well as the concerned key actors:

Policy action	Primarily addressed actors			
	Sector	Policy	Administration	Research
Continuous observation of climate change impacts on IWT and their quantification	x	x	x	x
Support the adaptation and modernisation of IWT fleet		x		x
Development of adaptation measures for infrastructure and improved hydrological predictions			x	x
Development of a state-of-the-art waterway system through cooperation between waterway administrations			x	
Permanent and pro-active cooperation of river commissions			x	
Preparation of ports for efficient handling of adapted/modernised vessels	x		x	x

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