DELIVERABLE 2.2.1
OVERVIEW OF ADAPTATION STRATEGIES

Final version

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Table of Contents

1. Introduction

Climate change may affect water levels and thereby also Inland Waterway Transport (IWT), e.g. in terms of decreasing load factors and increasing costs. Accordingly, one of the objectives of ECCONET is to identify the impacts on IWT e.g. in terms of possible additional costs and to identify and recommend measures to reduce the impacts. These measures – the ECCONET adaptation measures – are the topic of study in workpackage 2.

In task 2.1 different adaptation measures have been identified. These measures need now to be assessed on their contributions to climate change adaptation. To do so we need information about costs and benefits. In an earlier phase of the project the ECCONET consortium has developed a framework for assessment which defines effects and implicitly sets requirements for data collection (we refer to subtask 2.2.2 and deliverable 2.2.2 for a description of the assessment framework and its application). Much information has been collected. It is now useful to obtain an overview of adaptation measures and the available data. The list of adaptation measures has been discussed during a validation workshop (organised on November 2nd, 2011 in Amsterdam). At this meeting the completeness of the list and the feasibility of all adaptation measures have been discussed with stakeholders in inland waterways. This provided ECCONET with an useful review, and a first selection of feasible strategies which is input to the work in subtask 2.2.2 where a more in-depth assessment of the adaptation measures will follow.

This deliverable (D 2.2.1) gives an overview of measures, presents the main results from the adaptation workshop and identifies the most feasible measures. It is organised as follows. Chapter 2 presents an overview of adaptation measures and available information about costs and benefits. Chapter 3 reports about the validation workshop. Chapter 4 concludes and defines the most feasible/suitable adaptation measures.

2. The adaptation measures

2.1 Introduction

Climate change may lead to more frequent and longer periods of low and high water. This may cause problems to the inland waterway sector. Governments and industry may respond and adapt behaviour to mitigate these effects of climate change. For example shippers can increase volume of stock in order to avoid transportation during periods with extreme water levels. This also forces receivers of goods to respond. Transport service providers can change the fleet (e.g. light weight or smaller vessels) in order to reduce the draft of the average vessel. Moreover, waterway managers can adapt infrastructure in order to increase the water levels. Finally, seasonal forecasts and water level prediction methods could be improved, which will provide shippers and ship-owners with better information to adapt decision making (i.e. loading of the vessel (higher payload, e.g. reducing the safety margins) and managing storage capacity). This gives four different types of adaptation measures:

- Adaption of transport operations and vessels (deliverable 2.1.1)
- Adaptation of the waterway infrastructure (deliverable 2.1.2)
- Improvement of water level prediction procedures (deliverable 2.1.3)
- Adaptation of production processes and storekeeping (deliverable 2.1.4)

A detailed analysis has been carried out to define possible measures and identify potential costs and effects of each single measure (detailed results to be found in the deliverables listed above). Cost and effects are needed to carry out the next step where the assessment of measures will be done. We have developed a framework before the start of the identification work to know what type of data ideally needs to be collected allowing an adequate assessment. The assessment framework (which will be explained in more detail in D 2.2.2) focuses on the impact of the measures on water levels and the involved costs. Of course, wider effects on economy, safety and the environment should ideally also become available and included into the evaluation. However, this has been very difficult to obtain.
It is clear that all measures will be different in nature and have different costs and effects, now and in the future (e.g. year 2050). The following sections provide a short review of the main results of adaptation measures. Section 2.6 presents the resulting list of all identified adaptation measures with availability of data.

2.2 Technical and operational changes in inland waterway sector

Technical and operational changes may improve over time and allow inland waterways to transport the same amount of goods with lower water levels. Hence, this part of the ECCONET work on adaptation strategies focused on the identification of innovative measures in technical changes, operation of the fleet, and new logistic solutions. The analysis has resulted in the identification of 8 different measures (see Table 2.1). For a detailed description for each of the measures we refer to Deliverable 2.1.1.

	Measure	Primary effect	Comments and remarks
A1	Lightweight structures, e.g. high tensile steel, SPS etc.	Reduction of own weight ➔ lower draught weight savings / payload gained: appr. 50-200t	Lightweight structures are relatively sensitive to damages; further research on technical solutions expected (beyond ECCONET)
A2	Adjustable tunnel	Extension of navigability to lower water levels	Applicable only for a limited number of vessels (which are not yet equipped with tunnels) e.g. in combination with A1 (no stand-alone-solution)
A3	Side blisters	Reduction of draught; payload gained at low water betw. 115 and 260t	Rather theoretical approach; 'handling' difficult, esp. (de-) coupling of blisters; sensitive to damages
A4	Flat hulls (multiscrew vessels)	Considerable draught reduction of push boat from e.g. 1.7 to 1.4 m	Promising approach esp. for push boat technology, even though construction costs increase and propulsion efficiency decreases
B1	Small instead of large vessels	Small vessels are less low water sensitive than large ones due to lower draughts	Favourable only in case of low water levels, but rel. high transport costs in case of favourable water levels, when 'scale-effect' (economies of scale) could not be realised due to small units
B2	Upgrade of small, less sensitive vessels from daytime to continuous operation	Increase of performance of the smaller, less sensitive vessels in times of low water	Promising, as far as upgrading will succeed (adaptation of accommodation for enlarged crew)
B3	Coupled convoys instead of single propelled vessels only	Distribution of load to both units ➔ Reduction of draught; (or: increase of load capacity)	Promising approach; able to operate at moderate draught and also, to serve the trend to large units (scale effect) without increasing draught; high flexibility
C1	Strategic alliances between IWT and other modes	Co-operation with other modes: shift of cargo to other modes in case of low water	Possibilities limited due to expected 'barriers' and capacity limits (rail: infrastr. and rolling stock) and high price level of road transport

Table 2.1: Overview of fleet, transport and logistics adaptation options (source: Deliverable 2.1.1)

Measures addressed to fleet units aimed to analyse feasible reconstructions of existing units or changes in design of new units which would enable safe navigation in extremely shallow waters. It allows ships to take the same payload with less water depths. The analysis has focused on investment costs that are needed to compensate for a drop in water levels (in cm's). It appears that in most cases the effect of the adaptation measure depends on the ship type. For instance, flat hulls seem economically viable for push train concepts in particular. When looking at the other fleet unit concepts (for which information on costs and water levels is available), it seems that adjustable tunnels outperform side blisters and lightweight structures. This does not mean that the other measures are not promising. Flat hulls, continuous operation and coupled convoys are considered to be feasible.

Costs are relevant for the assessment within ECCONET, but also for the investor who decides about the investment (i.e. ship-owner). It appears that investments in innovations can be considerable, but may be long-lasting depending on the lifetime of the ship/investment. Note that fleet investments may coincide with changes in fuel and maintenance costs of the vehicle which will be included in decision making by the investor. These appear to be very limited and have therefore not been taken into account.

A relevant question is why these measures have not been implemented at present (although coupled convoys are current practice). The answer is perhaps twofold. The situation nowadays may not be considered as sufficiently critical, and climate change is not yet considered to be a real problem to justify the investments in these technologies by the sector. Another reason may lie in emphasised conservatism of the users (ship owners) and their caution to enter the risk of being the first who invest in improvement being only experimentally confirmed in laboratory conditions in model scale.

Also the B-group of measures addressed the improvement of the ship operation in case of less favourable water levels. Continuous operation instead of daytime operation seems a feasible solution in the short run as it is not very expensive and rather easy to implement. Another solution goes into the direction of smaller ship sizes. These are considered to be less efficient (scale decreasing) and are therefore not viable in current situations where water levels below 1.75 draught are rare.

Inland navigation may also look for cooperation with other modes as an alternative to days with low water levels. Shippers and/or ship-owners may cooperate with trucking and/or railway companies to better respond to situations (e.g. guarantee a certain amount of capacity). Literature (elasticities) and empirical evidence (blockage of Rhine navigation after tanker capsized) from a survey amongst ship-owners suggest that alternative modes are not a realistic option in the short run. There might be uncertainty about the duration, and competing alternatives are usually more expensive and have no capacity readily available. Depending on the type of goods, it appears to be more cost-effective to wait, accept higher freight prices for barge services or to keep products in store rather than to choose other transportation modes. Costs and effects of this last option depend very much on the situation and are therefore difficult to assess.

2.3 Infrastructure

Waterway infrastructure can be adapted to maintain water levels, even in dry or wet periods. These works may focus on certain bottlenecks where water levels are relatively low, such as Kaub or Ruhort. The analysis in Deliverable 2.1.2 has focused on maintenance of waterways, which implicitly implies that large infrastructural works (such as dams or artificial basins) are not seriously considered as being necessary or feasible for climate change adaptation. Maintenance focuses on certain stretches and has to fulfil international agreements to allow unhindered navigation on both Danube and Rhine. Waterway administrations must prepare dedicated adaptation strategies for the short-, medium- and long-term perspective. This also means that a certain water level should be maintained. The analysis in D 2.1.2 focuses on the Danube, but results can be transferred to the Rhine as well.

The central waterway infrastructure element is the fairway, which is established by means of river engineering elements (groynes, training walls, rip-rap) and maintained by means of surveying activities, dredging and information activities. A combination of these activities may lead to measures that will be considered to prevent low water situations and increase water levels. The following adaptation measures have been identified:

- maintenance adaptation measure: combination of surveying, dredging and information provision as well as possibilities for better exploitation of the fairway available, e.g. fairway-within-the-fairway;

- river engineering measures (modification or creation of groynes, training walls, rip-rap facilities) involving continuous monitoring of their impacts adjusted to possibly accelerated changes of the water regime in question.

Costs and effects of these measures very much differ and depend on the length and morphology of the river section/bottleneck that needs to be maintained (or where water levels need to be secured) and the number of groynes, training-walls or rip-rap facilities that are needed or modified. Further, political developments, fulfilment of stakeholder interests in an integrative manner as well as more stringent environmental requirements involving complex procedures make an exact, reliable estimation of adaptation costs very difficult. Costs are presented for maintenance works, but cannot be linked to water level improvements. Larger structural river engineering measures have to be planned, evaluated and executed in the framework of dedicated infrastructure projects, considering local framework conditions.

2.4 Improved procedures for medium and seasonal water level forecast

Besides changes to fleet and infrastructure maintenance measures, also the provision of additional or improved information about the water levels is considered as an interesting adaptation measure. Weather predictions and water level information is crucial to any journey planner deciding about the payload of inland vessels. The sector gives great value to a reduction in uncertainty of water level forecasting (which gives more accurate long-term predictions). The stakeholder workshop confirmed the great interest of the sector in more reliable forecasting.

Deliverable 2.1.3 has provided a literature review which gives an overview of the current state-of-the-art in research related to meteorological forecasting and the possibilities to improve these. It appears that dynamic models are currently in use to predict weather. There is potential to improve forecasts using empirical models and methods as well, but generally dynamic models are considered to be of higher quality.

Other potential improvements to forecasting lie in the sources of predictability. On the shorter time scales, improvements to the land surface including the method of soil initialisation have been proven valuable. In the long run large scale circulations have become important, and the challenge is now to measure the impact of climate change on these phenomena. This indicates that there is room for improvement of meteorological forecasting in Europe, which could also be beneficial to inland waterway navigation.

Coupling of meteorological and hydrological model systems can also be improved. This mainly refers to the combination of short-term, medium-term and long-term forecasts, and the cooperation between national and international institutes. Coupling of meteorology and hydrology has been done already by several research groups and their results are promising for reaching a medium- to seasonal range forecast.

The attractiveness of improved forecasting for the shipping industry as an adaptation strategy to longer and more frequent periods of low water levels is apparent. The previous overview indicates that there are possibilities for improved forecasting. However, it is difficult to assess the costs and effects of this adaptation measure and make this comparable to the other types of adaptation measures. It is concluded that costs for running a forecast system cannot be quantified. But it might well be that improved forecasting methods may be very beneficial to society. Cost reductions due to better knowledge of seasonal previews of water levels might be very high.

2.5 Adaptation of production processes and storekeeping

Subtask 2.1.4 has dealt with the identification of adaptation related to the shipping sectors e.g. in terms of creating larger storage capacity by firms, relocation of production processes and alternative transport (which has also been addressed in subtask 2.1.1). Deliverable 2.1.4 focuses on a literature review and presents results from a survey amongst shippers (which may hire ship owners for transportation, or have their own fleet) carried out within the ECCONET framework. It concludes that - apart from temporary production reductions - the use of alternative transport modes, adaptation of the fleet (ship-owners), and extension of the storage capacity, are the most favourite adaptation measures amongst shippers. Although additional capacity at other modes might be limited (as found earlier in D2.2.1), this strategy is preferred by most shippers. Adaptation of the fleet will take much time, but is still preferred above extension of the storage capacity. Extension of the storage capacity will imply huge investment of the shippers, whereas the benefits are unsure due to uncertainties in the occurrence of low water events in the future.

Many studies show that the cost of low water events or blockades of the Rhine for the IWT-sector, the shippers and society in general (welfare losses) are relatively high. Nevertheless, the willingness of shippers to take adaptation measures to prevent such costs seems to be relatively low. A main reason for this low pro-active behaviour might be the uncertainty about the occurrence of low water events in the future. At present, the results of climate scenario's and hydrological models show too many uncertainties for the shipping sector to make reliable calculations about costs and benefits of adaptation measures such as a - partial - shift to the more expensive transport modes (rail and road) , adaptation of the fleet (smaller/lighter ships) or extension of the storage capacity. Furthermore, the risk of the increased costs of low water events or blockades is spread among the stakeholders: shippers, operators, and in some cases even insurers. Of course each stakeholder will pass his costs on to the client. If an operator buys lighter ships he will transfer the costs into his rates for shippers, etc. But he still has to offer a competitive rate, so he is dependent on the behaviour of other operators.

The analysis suggests that shippers will not show too much of adaptive behaviour. Given the uncertainties about expected low water events, they are unable to make a well-considered investment decision about costs and benefits. In such situation most economic agents will take a defensive position instead of behaving pro-active. This means that shippers will be rather reserved to invest as long as this uncertainty exists.

2.6 Review of adaptation measures

The previous sections have discussed different types of adaptation measures. The following table (table 2.2) gives an overview of all identified measures, and shows availability of effect data and makes some remarks about the potential of the measures (if possible).

We have identified 13 different measures. The analysis (literature reviews and empirical survey work) of the adaptation measures reveals which measures have relatively more potential than others. Investments in a more efficient fleet are possible, which allows the same weight to be carried with lower water levels. We find some mixed results on the use of other modes. Ship-owners seem to be less optimistic (which may have to do with their position), whereas shippers consider modal shift as one of their first options. There is also a difference between goods types. For some it may be very expensive and less feasible in the short run due to limited available capacity.

Infrastructure maintenance strategies may be intensified/improved to prevent low water periods. But also continuous operation has potential, especially because of the low costs. Prediction methods are continuously improved, which are relevant to the inland shipping sector. However, it is difficult to quantify and express the effects this can bring in terms of water levels. Because low water periods are usually temporarily, storekeeping or postponement of transport is one of the first options. So far, the level of urgency is not sufficiently high to invest in these adaptation measures, which explains why they have not been seriously considered in this stage.

Category	**Adaptation measure**	**Cost information**	**Impact on water levels**	**Other effects**	**Remarks**
Technical and operational changes	Lightweight structures	Yes	Yes	Not available	Maintenance costs relevant?
Technical and operational changes	Adjustable tunnel	Yes	Yes	Not available	Maintenance costs relevant?
Technical and operational changes	Side blisters	Yes	Yes	Not available	Maintenance costs relevant?
Technical and operational changes	Flat hulls	Not available	Not available	Not available	
Technical and operational changes	Small instead of large vessels	Not available	Not available	Not available	High transport costs
Technical and operational changes	Continuous operation	Not available	Not available	Not available	Relatively low cost measure
Technical and operational changes	Coupled convoys	Not available	Not available	Not available	Considered promising
Technical and operational changes/ storekeeping	Strategic alliances between IWT and other modes	Not available	Not available	Not available	Mixed results
Infrastructure investment/maintenance	Maintenance measures	Yes	Indication available (20-30 cm)	Not available	Focus on Danube
Infrastructure investment/maintenance	River engineering	No	Indication available	Not available	Focus on Danube
Prediction methods	Prediction methods	Not available	Not available	Not available	High potential for sector
Storekeeping/relocation	Storekeeping	Not available	Not available	Not available	Option when capacity available, otherwise costly
Storekeeping/relocation	Relocation of production process	Not available	Not available	Not available	Long term option

Table 2.2: Overview of adaptation measures and available data

When we look at the information needed for the assessment according to the evaluation framework, it appears that a limited amount of information is available for costs and effects. Only for some fleet adaptation measures and maintenance, information has been collected about (investment) costs and savings in cm's of water levels. This does not mean that other measures will not be considered. A more detailed assessment based on costs and effects will be done Deliverable 2.2.2. Here we focus on the availability of information.

3. Stakeholder workshop

ECCONET has organised an adaptation workshop in November 2011 in Amsterdam. The meeting aimed to inform inland navigation stakeholders about the ECCONET work, but also to have their opinion about the feasibility of the different adaptation measures as identified in the previous chapter. Stakeholders who attended the meeting included port of Antwerp, sector organisations (EVO, Schuttevaer), transporting companies (e.g. Tata Steel, Cargill) and governmental organisations (DVS, waterway owner in the Netherlands

(chapter 3 has been edited from its original version, the report from the stakeholder workshop is not public)

4. Conclusions on adaptation strategies

ECCONET has identified 13 different adaptation measures in WP 2. These range from changes in the fleet to relocation of production plants. Stakeholders have confirmed that these are the most relevant measures which they would consider when confronted with worsening circumstances in either the Danube or the Rhine. The availability of information (of costs and effects) is different for the various measures. This Deliverable only provides an overview of adaptation measures with a first identification of feasible and less feasible measures based on a literature review, empirical work and stakeholders' opinions. A final selection of most promising measures within the ECCONET context of modelling adaptation measures with NODUS is described in Deliverable 2.2.2.
The following table identifies the level of feasibility according to two sources of information. The final column gives an overall assessment on feasibility and indicates whether it is considered feasible or less feasible. This is input to D2.2.2 where a selection will be made for assessment with NODUS application.

Adaptation measure	**Review**	**Stakeholders**	**Overall assessment adaptation measure**
Lightweight structures	Feasible	Feasible, but only for ship owners	Feasible
Adjustable tunnel	Feasible	Feasible, but only for ship owners	Feasible
Side blisters	Feasible	Feasible, but only for ship owners	Feasible
Flat hulls	Feasible	Feasible, but only for ship owners	Feasible
Small instead of large vessels	Feasible, but not realistic	Not realistic	Less feasible
Continuous operation	Feasible	Feasible	Feasible
Coupled convoys	Feasible	?	Already taking place
Strategic alliances between IWT and other modes	Depending on stakeholder/industry /type of goods	First option	Feasible
Maintenance measures	Feasible and needed	Feasible and necessary	Feasible
River engineering	Feasible and needed	Feasible and necessary	Feasible

Prediction methods	Feasible	Important	Necessary, not really adaptation measure for sector
Storekeeping	Feasible	Feasible, not attractive for all sectors	Feasible in short run when capacity available, otherwise costly
Relocation of production process	Less feasible	Less feasible	not feasible in context of climate change

Table 2.3: Overview of adaptation measures and corresponding assessments