# DELIVERABLE 2.1.4
# ADAPTATION OF PRODUCTION PROCESSES AND STOREKEEPING BY SHIPPERS

Report for:
**European Commission**
**Directorate-General for Energy and Transport**
1049 Brussels

January, 2012


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# 1. Introduction

Subtask 2.1.4 deals with the identification and the analysis of promising adaptation strategies and concrete measures to be taken by shippers:

- technical changes of fleet (smaller or lighter vessels: see also task 2.1.1 for technical implications);
- larger storage capacity (postponement of transport);
- alternative transport;
- reduction or shutdown of the production process;
- relocation of the production process.

Besides shipper related adaptation measures as listed above, the Task 2.1 will consider measures dealing with technical adaptation of the fleet (2.1.1), adaptation of the waterway infrastructure (2.1.2), and the improvement of water level prediction models (2.1.3). As far as the results of all these, in their nature quite different groups of measures have to be assessed upon their effects (Task 2.2), it was necessary from the very beginning of the WP2 working activities to establish a universal scale to evaluate and mutually compare estimated effects of each particular measure. The main problem thereby was that the future changes of hydraulic parameters of the free flowing waterways cannot be determined in precise and explicit form. The estimated scenario assumes a certain drop of the waterway levels and bigger amplitude of the annual waterway variations referring to those nowadays. A specific problem for task 2.1.4 is that - whereas technical measures such as fleet adaptation, waterway infrastructure adaptation, and water level prediction models can be expressed in cm gained or lost, the adaptation measures of shippers are expressed in durations. Which additional period of time the production process is not harmed by shortages of supply of inputs when the storage capacity is extended by x tons?

In this deliverable we will present a brief literature review of recent studies on adaptation measures to be taken by shippers in section 2. Then we focus on our own research. In section 3 we discuss the structure of the questionnaire and make a response analysis. In section 4 we present the results of the questionnaire. In section 5 we conclude. The letter of recommendation, both in English as in German, and the questionnaire in German can be found in the Annexes (the questionnaire in English is discussed in section 3).

# 2. Adaptation measures by shippers: a literature review

The literature reveals a large number of adaptation strategies to cope with the impacts of low water events (due to climate change). These adaptation strategies concern various stakeholders.

- Operation of excess capacity in the fleet (operators)
- *Higher speed or number of operational hours per day of the fleet (operators and shippers with own fleet)*
- Improvements in the waterway infrastructure (government, deliverable 2.1.2)
- Improved prediction measures to anticipate on changes in the water level (operators and shippers with own fleet, see also deliverable 2.1.3)
- *Alternative use of modalities in the logistic chain (shipper, see also deliverable 2.1.1)*
- *Alternative use of suppliers (shipper, see also deliverable 2.1.1)*
- Adaptation of the fleet (operator and shipper with own fleet, deliverable 2.1.1)
- *Additional storage capacity at production location (shipper)*
- *Reduction or stop of production (shipper)*
- *Relocation of production (shipper)*

In the literature review we will focus on those adaptation measures where shippers are stakeholder (the items in italic in above list). Nevertheless, when shippers own their own fleet, they are operators as well. When shippers operate their own fleet they become operators and thus there is quite some overlap with other deliverables of workpackage 2.

Before starting the review on adaptation measures that could be taken by shippers we will give a brief overview of the characteristics of inland waterway transport on the river Rhine in section 2.1. In section 2.2 we will provide some information about the costs of hindered navigation due to low water events. Stakeholders will only adapt if the costs of low water events outweigh the costs of adaptation measures. Therefore it is important to have information about the costs of hindered navigation before presenting the adaptive behaviour of stakeholders.

This literature review is mainly based on the work of my predecessor Olaf Jonkeren (2009, 2010), the work of Anja Scholten (2009, 2010) for KLIWAS and her PhD, and the work of NEA (2011) on the impacts of the closure of the Rhine at the Lorelei Rock.

Before starting the literature overview we will first give the general information about these studies.

Jonkeren (2009, 2010) has carried out a lot of research in the field of adaption to climate change in inland waterway transport. He finished his PhD thesis on this topic in 2009 and worked on the research program Knowledge for Climate financed by the Dutch national government, before starting with Ecconet. Amongst others, Jonkeren interviewed 6 shippers and 2 operators about the effect of low and high water levels on reliability and costs of inland waterway transport and their responsive behaviour.

Scholten (2009, 2010) wrote - amongst others - a PhD thesis on this topic. An important element in her work was a questionnaire send to 247 firms located at the river Rhine. The majority of the firms is located at the Lower Rhine (134), followed by the Upper Rhine (81). 62 firms returned the questionnaire. The firms located at the Lower and Upper Rhine were well represented, respectively 36 and 21 responded, the firms located at the Middle Rhine were underrepresented (only 5 responses). The majority of the firms located at the Lower Rhine are steel or chemical companies. At the Upper Rhine chemical companies are overrepresented. Scholten focussed her questionnaire on storage capacity, modal shift, reduced production and relocation due to low water events. She asked about past experiences and future expectations in the light of climate change.

NEA (2010) studied the damage to the inland water sector of the blockade of the river Rhine by the capsized tanker Waldhof from 13th January until 14th February 2011. A blockade of the Rhine is to a large extent comparable to a navigation ban due to a low water event. An online survey among IWT operators was held. In total 74 ship owners responded to calls via SMS, Twitter, and e-mail through the various IWT umbrella organisations. NEA focussed its research on direct losses due to queuing, modal shift, hindered production and stockpiling.

## 2.1 Inland waterway transport on the river Rhine

The mode inland waterway transport has a substantial share in modal split of the Netherlands, Belgium and Germany: 33, 16, and 12 per cent respectively. The most important waterway is the river Rhine on which 63% of all inland waterway transport in Europe takes place (Jonkeren, 2009).
According to the questionnaire of Scholten (2010) for firms located at the Rhine, the main indicators for the choice of transport mode are: price, infrastructure (of clients) and the demand of clients. Nearly 80% of the firms indicated price as important in the selection of transport mode. A second group of indicators are reliability, transport safety, and volume. The least important indicators are distance, speed and environmental indicators (for instance weather conditions). When the importance of the indicators volume and the environment increases, so does the importance of inland waterway as mode of transport. The environment plays an important role in the reliability of transport modes. Inland waterway transport is sensitive for high and low water, however, its operation is hardly affected by snow and storm. Road and rail transport are more sensitive for such weather conditions. Although the inland waterway is relatively slow and thus less attractive for the transport of perishables, it is relative reliable considering just-in-time deliveries for all other goods. Considering the safety of transport, inland waterway performs the best. Inland waterway transport is probably the best option for the cheap transport of low value goods for which speed is no issue, such as raw material and construction materials.

The share of inland waterway transport for inputs of the 62 firms researched by Scholten (2010) is rather large (47%); the share for outputs is with 24% considerably lower. The share of road transport shows the opposite pattern (25% inputs, 61% outputs). In particular the energy sector is depending on inland waterways for their inputs (85%). Inland waterways are mainly used for the import of large flows of raw materials from the Amsterdam-Rotterdam-Antwerp (ARA) harbours. Those goods are transported without transhipment to the production plant. The good flows to the clients are much smaller implying that road transport is the obvious transport mode. Jonkeren at al. (2010) find in their research a much higher share of inland waterways of about 60%. However, this finding is based on only 12 questionnaires.

The impact of low water events on transport costs and volume is considerable. Krekt et al. (2010) summarize the findings of the Dutch research program Knowledge for Climate. Based on the rather extreme KNMI W+ climate scenario, they expect an annual increase in transportation costs between 9% and 23% by the year 2050. For 2050, they expect that 86% of the total volumes of inland waterway transport within, to, from and through the Netherlands would not be affected by the impact of the W+ climate change scenario. From the 14% of the inland waterway transport that would be hindered, half becomes unreliable because the goods cannot be delivered at the planned moment. The other half (7%) is still feasible, but under increased generalized transport costs. A modal shift of 8% of the total annual volume is expected, of which 88% to rail and 12% to road. The remaining 6% of the annual volume will be lost.

In the research of Scholten (2010), 53% of the firms stated to have had experiences with low water levels in the past. 23% of the firms experienced problems with high water, and 6% with heat (a shortage of cooling-water that often occurs in combination with low water levels).
Unfortunately, Scholten (2010) was unable to find significant relations between experienced low water events and economic sectors and/or transport characteristics of the firms researched. Scholten tested four hypotheses:

1. By increasing frequency and regularity of supply, a firm will be increasingly affected by extreme events;
2. By increasing vessel size operated, a firm will be increasingly affected by extreme events;
3. The longer a firm can produce without deliveries, the less it is affected by extreme events,
4. By increasing access to transport modes, the impact of extreme events decreases.

Only the 3rd hypothesis proved to be significant (at the .25 level) in case of experiences with extreme low water events.

Scholten (2010) asked the firms about the expected impact of climate change on the occurrence of extreme events in the future. 69% of the firms expect an increase in the occurrence of extreme events, many of them refer to the low water event of 2003. The remainder did not expect any impact of climate change. Although 69% expect more regular extreme events in the near future, only 24% of them already took actions. Another 17% prepare actions, but the majority (59%) have no intention to undertake any adaptation measure at all. The adaptation measures mentioned were: extending storage capacity and a modal shift from inland waterway to rail and road (Scholten, 2010).

## 2.2 Costs aspects of low water events

In general, an economic agent will only show adaptive behaviour when the costs to adapt are less than the costs they are imposed to. Of course this general rule also holds for stakeholders in the inland waterway transport who are confronted with an increase in transportation costs due to low water events. Thus the first question should be: are operators and shippers confronted with higher transportation costs due to low water events?
Jonkeren & Rietveld (2009b) asked shippers about their experiences with high and low water events. It appears that all 6 shippers interviewed have experienced an increase in transport costs and five out of six shippers observed a decrease in reliability of inland waterway transport as a result of low and/or high water events in the past.
Based on the experiences of the firms, Scholten (2010) concludes that low water is a transport - and due to that a cost - problem. Low water can extend delivery times and lead up to a 70% reduction of the capacity of vessels. As a consequence, the cost per tonne, and thus also the price per tonne transported will rise (Jonkeren & Rietveld, 2009a). Note that this effect of the water level on the transport prices is only present when water levels drops below a certain threshold. Be aware that this threshold differs for the various ship types. Low water surcharges as high as 100% of the normal transportation costs are mentioned by shippers. Jonkeren (2009) calculated for the Kaub related Rhine market that for an average inland ship the transport price may increase with 74% in periods with very low water levels. Jonkeren et al. (2007) estimates an increase in annual transport costs due to low water events on the river Rhine of about 15% in a year which is more or less representative for the extreme KNMI W+ scenario for 2050. Jonkeren (2009) estimated that in the period 1986-2004 there has been an annual average welfare loss of €28 million due to low water levels in the Kaub related Rhine market. The estimated loss in the extreme dry year 2003 was estimated at €91 million. Extending the average estimation (€28 million) to the total Rhine market, Jonkeren finds a welfare loss of €227 million. Min.

V&W et al. (2005) estimated the costs of low water for Dutch inland waterway transport at €111 million in 2003.

NEA (2011) estimated the average damage per ship including insurer costs, unemployment costs and share paid by shipper/forwarders of the blockade of the river Rhine near the Lorelei rock in January-February 2011. Based on a survey among 75 IWT operators they estimate an average damage of €40.000 per ship. Given a total queue of 475 ships, the total damage due to involuntary delay would amount approximately €19 million. The impact of the blockade of the river Rhine due to the capsizing of the tanker Waldhof is comparable to a navigation ban due to a low water event.

Even firms that are not directly affected by low water levels, are indirectly affected by reduced vessel availability on the inland waterway market (Scholten, 2010). Due to the reduced availability of vessels the price of inland waterway transport rises. Additional, low water might lead to shortages of cooling-water, forcing firms to reduce production, even if sufficient raw materials are still available.

Important to note is which stakeholder the cost increases in inland waterway transport bear. Jonkeren & Rietveld (2009b) came to the conclusion that the extent to which shippers are confronted with cost increases is partly dependent on what is agreed upon in the contract with the operator. In four out of six interviews with shippers it appears that the risk of not being able to navigate is - at least partially - internalised by the operator. Both operators interviewed by Jonkeren & Rietveld (2009b) confirmed that the costs of lying still are borne by the operator and the client (shipper).

The study of NEA (2011) shows that many stakeholders are involved in bearing the costs of a navigation ban. Operators, insurers, shippers/brokers and government absorbed part of the damage of the blockade. NEA found that about 40% of the operators work under a contract for a longer term, 60% work on a trip basis. In their survey, about 50% of the operators working under a contract for a longer term, mention that losses due to involuntary waiting were shared with shippers/forwarders, in most cases on a 50% loss-sharing ratio.

## 2.3 Higher speed or number of operational hours of the fleet

In periods of low water level, inlands ships are restricted in their load capacity. A part of this loss of cargo will not be transported by inland waterways because of capacity constraints of the fleet and another part because it will shift to competing modes. However, additional gains are to be achieved when the inland fleet navigates at higher speed[1] or make more hours per day.

Higher speed implies a disproportionate increase in fuel consumption which is only an option in periods with high freight prices. Low water events do lead to higher freight prices (see section 2.1). However, Jonkeren (2009) shows that there exists a small effect of transport prices on navigation speed. A 10% increase in transport price leads to an increase in navigation speed between 0.03 and 0.3%. One of the operators interviewed by Jonkeren & Rietveld (2009b) mentioned an increase of the navigation speed as a short term adaptation measure. However, Jonkeren (2009) shows that barge operators do not increase navigation speed structurally, but prefer to increase the number of operational hours per day.

In inland waterway transport in North West Europe three exploitation forms exists: A1 (14 hours), A2 (18 hours), and B (24 hours) of operation per day. Each exploration form requires a specific size and composition of the ship crew (Jonkeren et al., 2010). About 25% of all inland waterway carriers operate on a 24 hour basis (Jonkeren, 2009). This implies that 75% of the fleet is able to increase the number of navigable hours per day during low water events, conditional to the availability of crew. The problem is not only the availability of crew, but also for what time period the extra personnel must be hired as it is

[1] It has to be considered that in case of lower water levels higher speeds are – from navigational and operational view – possible only to a limited extent. In practice, rather lower speeds apply.

hard to foresee how long the low water event will last. Jonkeren et al. (2010) applied cost-benefit analysis to find out if the extra revenue which is generated by navigating more hours per day compensates for the extra costs (labour, total fuel and maintenance costs). They find that for the extreme KNMI W+ climate scenario, navigating more hours per day is an economic feasible adaptation measure. Given several assumptions, their explorative welfare analysis demonstrates that the benefits outweigh the costs by €7.44 million per year. However, if this conclusion holds for all climate scenarios is questionable. They argue that if benefits increase disproportionally when water levels decrease, it may be that in milder climate scenarios benefits do not outweigh costs (Jonkeren et al., 2010). In Ecconet we applied less extreme climate scenarios, so it is not clear if the results hold for our findings.

## 2.4 Additional storage at production location

Storage capacity gives a first hint of the vulnerability of an inland waterway transport dependent producer if transport is hindered by low water events. How long a company might be able to produce without or with limited transport differs by company, industry, and location.

According to Scholten (2010), the number of days a firm can produce without the delivery of inputs strongly depends on the storage capacity of raw materials of the firm. However, due to capital costs of raw materials, the storage capacity is in most not fully utilized. Scholten finds in her questionnaire among 62 shippers that 32% of the firms can continue to produce without deliveries for over two weeks, 25% between one and two weeks, and another 18% between 4 and 7 days. However, 24% of the firms need deliveries within 4 days to secure the production process. There are differences between sectors considering the dependency on deliveries. The energy sector, the coal and steel industry, the construction material industry are less depending on regular deliveries then, for instance, the food sector (perishables), semi manufactures, and refineries (Scholten & Rothstein, 2009). Scholten (2010) concludes that optimal use of storage capacity could be realized when better forecasts about low water periods (and duration) become available (this topic is discussed in deliverable 2.1.3). Given the improved forecasts, firms can anticipate by filling their input storage and emptying the output storage in advance of low water periods.

Jonkeren et al. (2010) go one step further in their analysis on how company characteristics relate to the decision whether to invest in additional storage capacity for bulk cargo in order to reduce the probability of an out of stock situation during periods with high or low water levels under future climate conditions. They analyse the trade off that is being made by a manager between, on the one hand, the cost saving of paying less for inland waterway transport and the reduced risk of production process interruptions during future low water events and, on the other hand, the costs of investing in additional storage capacity. They invited 220 potential respondents to fill out an online questionnaire (in English and German). Only 12 respondents filled out a complete questionnaire, allowing them to make a descriptive analysis. The respondents were told that the extreme low water event of 2003 would occur every year by the year 2050. Eight out of twelve shippers experienced problems in 2003. The most often mentioned measures to cope with the low water event were: the payment of higher transport prices, reduced production and modal shift. On the question whether respondents were planning to invest in extra storage capacity, the answers were 'don't know' (4 respondents), 'no' (5) and 'yes' (3). However no clear relation could be found between the low water event in 2003 and the investment in extra storage capacity: 2 out of 3 shippers that answered 'yes' did not experience problems related to the low water event of 2003. The three shippers that are planning to invest in extra storage capacity indicate that the more upstream location of the firm and the larger a shippers' dependency on inland waterway transport, the more likely the shipper is to invest in additional storage capacity.

In the research of Scholten (2010), the expansion of the storage capacity as adaptation measure is not included. However, some of the firms mentioned it as an additional adaptation measure, though only as a final solution, given the high costs.

In the interviews of Jonkeren and Rietveld (2009b) only two out of six shippers mention a storage capacity related adaptation measure. One shipper states that investing in extra stock facilities at the production facility could be an option in the case that the extra transport costs by inland waterways outweigh the investment costs. The second shipper uses push barges as temporary stock facility. This shipper plans to put empty push barges close to the production facilities. The advantage is that the extra stock capacity is hired temporarily, whereas the rent for a warehouse has to be paid during the whole year.

Quite interesting, NEA (2011) researched the opposite of shortages of stock at the receiver: they studied stockpiling at the sender. They found evidence of stockpiling for some oil companies and steelworks. Also in the Port of Rotterdam stockpiling occurred, for instance of containers. NEA concluded that both dispatchers and recipients on both ends of the transport chain suffered from damage due to the closure of the river Rhine. Based on the sparse input data NEA estimated that the order of magnitude of the damage varies between millions and tens of millions of euro. However, due to this uncertainty, they did not monetize the hindered production.

## 2.5 Alternative use of modalities in the logistic chain

For years, the transport policy of the European Commission is aiming to establish a structural modal shift from road transport to railway and inland waterways, in order to reduce the emission of greenhouse gasses. However, will low water events due to climate change lead to a reverse development? Inland waterway transport prices increase as the water level decreases. In addition, the reliability of inland waterway transport is likely to deteriorate due to low (and high) water levels. Bfg (2006) found a reduction in inland waterway transport volume of 5.1% in 2003 compared to 2002. Furthermore, they noted that in the years after 2003, inland waterway transport won back the tonnes lost in 2003 on the competing modes.

Jonkeren (2009) modelled the model split using NODUS, for the Kaub related Rhine market, under several climate scenarios. It turned out that the effect of higher transport costs on the model split is limited. Under the extreme KNMI W+ scenario, inland waterway transport would lose about 5.4%. Note that the impact of decreased reliability is not taken into account in the modelling exercise. Jonkeren & Rietveld (2009b) find that inland waterway shippers are rather time sensitive for inland waterway deliveries. Three out of six shippers mentioned a time span of between 0 and 4 hours from the agreed arrival time, one within 1 hour, one within 1 day and the last within 3 days.

Nomden & Deursen (1999) interviewed a shipper who stated that shippers of dry bulk will not choose for competing transport modes due to increases in transport costs. Inland waterway transport is considered to be about 50% cheaper than transport by competing modes.

In addition to this single example, more extensive interviews on this topic are applied by Scholten (2010). Jonkeren (2009) and NEA (2011).

Modal shift is, from a technical point of view, an option for most firms interviewed by Scholten (2010). 16% of the firms - most of them chemical companies - are accessible by all modes of transport (inland waterway, road, rail and pipeline), 53% by three transport modes, and 25% by two. Unfortunately, Scholten did not research to what extent firms were actually able to shift to other transport modes. Is capacity at another transport mode available on a short notice? To shift, for instance, from inland waterway to rail, both rolling stock as well as rail infrastructure capacity must be available, regardless of the fact the firm is accessible by rail as studied by Scholten.

Scholten & Rothstein (2009) state that many firms are willing to transfer their cargo to smaller or more vessels, to trains and trucks during low water periods. However, they argue that at normal water levels the use of new, small vessels makes little economic sense, which is why relatively few small ships are available (small vessels cannot realize size effects (economies of scale)). Furthermore, they argue that rail and road freight traffic has only limited free capacity, as well meaning that the volume that can be transferred here is also limited.

The six shippers interviewed by Jonkeren & Rietveld (2009b) all mention the use of alternative transport modes (rail and truck) as a short term reaction to interruptions in inland waterways, although for some shippers railways is not always an option. One shipper states that railways are a bad alternative because he considers the reliability of this mode to be poor. In addition, the capacity that is offered by those alternative modes (rail and truck) is usually less than the capacity offered by inland waterways. As a consequence, every day that barges cannot be used, stocks at production locations decrease.

In case of the blockade of the Rhine due to capsized tanker Waldhof, NEA (2011) estimated the amount of transport that was transported by an alternative mode. They focussed on time-critical - high value - goods. NEA takes into account: 1) opportunity costs of capital due to the fact that some delays occurs to organise the alternative transport, and 2) the higher transport prices of those modes. NEA estimates those costs at €1 and 22 million, respectively. Based on interviews with port companies and stevedores NEA concludes that for a part, cargo shifted to road and rail transport, but especially rail could offer limited extra capacity.

NEA (2010) also provides some information at the sectoral level. For some routes, oil companies used rail or pipelines as alternatives. For the transport of oil products, IWT is 50% cheaper than rail transport. Scholten & Rothstein (2010) conclude that the decision of Frankfurt airport to be directly connected to the pipeline net from Rotterdam might have been influenced by the experiences made during the low water period in 2003. In 2003, Frankfurt airport needed 31% more ships, compared to the ideal water levels, to secure the kerosene demand. According to NEA (2010), steelworks used rail and road as alternative modes, although these were much more costly. Fertiliser producers used road transport for both the purchase and delivery of products.

NEA also asked the 74 ship owners if they seriously considered alternative transport during the blockade of the Rhine. The majority of 43 firms did not consider alternative transport. Their main reasons were: 1) uncertainty about duration (24 firms), 2) too expensive (14 firms), and 3) no capacity available (10 firms). All those arguments would hold as well in the case of an low water event. During low water events it is possible that 'normal' navigation can soon be restored and although waiting involves additional costs, these costs are probably smaller compared to shifting to another mode of transport. Many ship owners consider (or assume) that a modal change would be rather expensive and that the available capacity of other modes is limited. This might be perceptions, but they may as well be formed by experience. Of the 31 companies who did seriously consider alternative transport, 22 made no use of alternative transport in the end. Of the remaining 9 companies that did change freight to other modes, 7 used rail and 6 road. Unfortunately, the additional costs of the use of the alternative mode remains unclear.

Based on the interviews with 74 ship owners, NEA concludes that future accidents or uncertainty caused by low water events is not something that is seriously considered as a reason for more cooperation with other modes to increase flexibility. A vast majority (93%) even indicates that future cooperation is not considered.

In addition, NEA mention that some shippers highlighted possible damage to the IWT as a reliable mode of transport. However, they were unable to monetize the costs of this damage. NEA concludes that the Waldhof accident did not directly lead to shippers or brokers leaving the IWT market, in exchange for rail or road.

## 2.6 Alternative use of suppliers

In the interviews of Jonkeren & Rietveld (2009b), one out of six shippers stated that during low water events use was made of an alternative supplier nearby. In such situations the goods are delivered by truck instead of barge. The increase in transport costs due to modal shift is limited due to the shorter distance to the alternative supplier. For the other 5 shippers, the use of alternative suppliers was no option. The use of alternative suppliers seems strongly dependent on the individual characteristics of a shipper and cannot be seen as a potential alternative for shippers in common.

NEA (2011) states that in case of the blockade of the river Rhine alternative (more expensive) suppliers of goods had to be found resulting in a loss of turnover and/or of higher costs for affected production industries. However, they were unable to estimate these costs for the 33 days of obstruction of the Rhine near the Lorelei rock.

## 2.7 Reduction or stop of production

Scholten (2010) finds that firms anticipate on a reducing stock of inputs due to low water events by either adjusting their delivery system or by reducing production. The delivery system can be adjusted by either using more or smaller vessels or by modal shift. The adjustment of the delivery system will always lead to additional transport costs. If a firm cannot afford the increase in transport costs, it will reduce production or in extreme circumstances even stop producing altogether. During long lasting low water events, often a combination of the afore mentioned measures is taken. In such cases, the production is temporally reduced by about 10%.

The findings of Scholten are confirmed by Jonkeren & Rietveld (2009b). Three out of six of the shipper interviewed state that the production is in danger due to low water events. The length and timing of the period may vary substantially. For one of them when he receives no deliveries for 5 days, the second after 14 days of no-deliveries, and the third only in the winter season. A fourth shipper states that non-delivery will lead to a standstill of production. A fifth shipper would have to downgrade the product, and the final shipper states that “the consequences will apply to the client, not to us” because he is the sender of the cargo and not the receiver.

## 2.8 Relocation of production

62% of the 62 firms investigated by Scholten (2010) are not willing to consider relocation due to the high costs of relocation and huge investments in the present location. However, 38% are willing to reconsider their location when their transport costs are affected structurally due to, for instance, climate change. Even more, Scholten states that she found indications that since 2003 for new plants, shippers selected (sea) harbours to increase their transport flexibility, regardless the impact of climate change.

Jonkeren & Rietveld (2009b) conclude that adaptive behaviour like relocation is not mentioned as a (potential) long term action by the shippers, even in the KNMI W+ scenario, where the effects are expected to be severe for some of the shippers. They continue to state that apparently, the costs and efforts associated with relocating are expected to outweigh the extra costs as a result of the low and high water levels.

## 2.9 Additional adaptation measures mentioned in literature

Other adaptation measures to cope with low water periods mentioned in the literature are:

- The onsite further refinement of the products into the direction of end products (chemical industry);
- The change of the composition of the product they make: the proportion in which different inputs are being used can be changed.

- Holding a higher safety stock level during the year.
- Postponement of inland waterway transport in case of a short low/high water period. According to NEA (2011) the postponement of transport leads to three additional costs: 1) the extra costs of storage, 2) capital costs due to the fact that goods are underway longer, and 3) higher transport prices due to intensified transport after the blockade (navigation ban) was over. NEA (2011) estimated those costs for the blockade of the river Rhine at €3, 2, and 1.4 million, respectively.
- Optimisation of the utilisation of the fleet: re-distribution of cargo over the available capacity.
- Adjustment of the logistical chain. The inland waterway transport is still used at the sections where navigation is possible, for the sections where navigation is no longer possible, alternative modes of transport are used. However, this implies an additional and costly transhipment of goods.
- Extending the fleet capacity to create a buffer. In periods in which part of the capacity is not being used, it is tried to rent the excess capacity to other shippers.
- The use of transport modes as additional storage capacity. However, the capacity is limited due to an increased demand for transport and a limited excess capacity of the fleet (ships, rail wagons and trucks).
- Insurances, either to cover increased transportation costs or to cover the costs of production reductions. Also such insurances are in most cases too costly.
- Development of risk management and/or emergency plans to be able to adjust in time.
- Adjustments of contracts with operators to secure deliveries.
- Adjustments of the contracts with clients in which the firm is not responsible anymore for the consequences for the client of non-delivery.
- New contracts with in particular rail operators.
- Approach the government to improve the inland waterways.

## 2.10 Conclusions of the studies considering adaption of shippers

In this section the main conclusions of the above discussed studies are presented.

Scholten & Rothstein (2010) conclude that the most important, most common adaptation measures of shippers are:

- Shifting goods to other transport modes;
- Deployment of additional ships and lighters;
- Deployment of smaller ships;
- Shut down of production (if no other options exist);
- Deployment of (intermediate) storage.

They conclude that companies which are situated along rivers often use inland waterway navigation as well as trains for transport. If one mode of transport is hindered, they try to switch to the other. Additionally, shifts of (small amounts of) goods to road transport took place.

The research of Jonkeren et al. (2010) focussed on three adaptation measures: 1) higher number of operational hours per day, 2) canalization of the river Rhine, and 3) additional storage capacity. They demonstrate that in the case of an increase of the number of operational hours the benefits outweigh the additional costs (fuel, maintenance, labour) in case of the KNMI W+ climate scenario by the year 2050. However, they cannot guarantee this conclusion also holds for less extreme climate scenarios. Canalization of the river Rhine will not be discussed here because it is no measure to be undertaken by shippers. Considering additional storage capacity they are unable to make a direct link between the experiences with the low water event in 2003 and the extension of the storage capacity. However, they do find a relation between the investment in extra storage capacity and the more upstream location of the firm and an increased dependency of the shipper on inland waterway transport. Unfortunately, due to the low participation of shippers this conclusion is qualitative and cannot be proven statistically significant.

In the Dutch research program Knowledge for Climate a list is given of short and long term actions to reduce the impact of high and low water levels on transport costs and reliability that could be undertaken by shippers (Krekt et al (2010) based on Jonkeren & Rietveld (2009b)):

- Using alternative transport modes (for the whole inland waterway transport route);
- Examining new logistical chains (partly inland waterway, partly rail e.g.);
- Postponement of inland waterway transport (in case of a short high/low water level period);
- Hiring extra capacity on the inland waterway spot market;
- Investing in stock facility capacity/higher stocks;
- Increase of the own fleet of inland ships;
- An increase of navigation speed (operator);
- Higher number of operational hours (operator);
- Transformation from barge-operator to container-operator (operator).

Krekt et al. (2010) state that the specific logistic solutions “higher number of operational hours” and “additional storage capacity” can be implemented at this moment, because they do not lead to large social, political or environmental consequences.

Krekt et al. (2010) draw some other important conclusions. They state that currently, direct users of the main shipping route to and from Germany (shippers, companies, ship-owners) are little aware of a potential increase in transportation costs and reduced reliability of waterway transport in the long term because they operate on a shorter time horizon. According to Kerkt et al. (2010), it is expected that players will respond to initial events as if these events were incidental. They are thus likely to seek ad hoc solutions. Greater frequency of events will force parties involved to consider more structural solutions. At present, shippers and transport operators expect the impact of climate change on inland shipping rather low. Companies will be more resilient, and better equipped to reduce damage after major disruptions and to return quickly to the original (or desired) situation, by taking measures as redundancy, flexibility, transparency and collaboration. If stakeholders wish to prepare themselves for the effects of climate change and other disruptions, a joint effort is required to accomplish this. However, if companies are hesitant to initiate this change, government or port authorities can stimulate this process (Krekt et al. (2010)).

# 3. The questionnaire

## 3.1 Structure of the questionnaire

The questionnaire is directed towards the river Rhine and its tributaries. In ECCONET we selected two critical locations in this river: Ruhrort and Kaub. Ruhrort is the critical location for inland waterway freight flows on the lower Rhine (at Ruhrort the water level is always the lowest on the stretch between Rotterdam and the Ruhr area), whereas Kaub is the critical location for inland waterway freight flows on the upper Rhine (at Kaub the water level is always the lowest on the stretch between Rotterdam and Strasbourg). The water level at Ruhrort is always higher than at Kaub. This means that ships able to pass Kaub are always able to pass Ruhrort.

Another point is that shippers might have their own fleet or use brokers (either by contracts or on the spot market).

All in all we had to develop four questionnaires combining the critical location involved and the ownership of the vessels:

- Lower Rhine shippers passing only Ruhrort using their own fleet;
- Lower Rhine shippers passing only Ruhrort using brokers;
- Upper Rhine shippers passing Kaub using their own fleet;
- Upper Rhine shippers passing Kaub using brokers.

The questionnaire was built in six sections:

1. Introduction;
2. Company data;
3. Freight flows, reliability and storage capacity;
4. Vessel types in operation;
5. Previous experiences with low water events;
6. Impacts adaptation measures future low water events.

*Ad 1: Introduction*

In the introduction of the questionnaire the context of the research project is explained. It states that the EU is funding ECCONET. It briefly sketches the expected impact of climate change on the water levels in the period 2021-2050, and discusses the range of adaptation measures available (fleet, infrastructure, storage, etc.) and the need to come to packages of adaptation measures that can count on the support of various groups of stakeholders (shippers, government, etc.).

Next, it is clearly stated what is in for the shipper to participate in the research. By filling out the questionnaire the shipper helps us to inform the EU how to improve the navigation conditions on the Rhine waterway system.

The introduction is rounded up by some instructions, the remark that all information will be dealt strictly confidential and contact details of Frank Bruinsma.

*Ad 2: Company data*

The requested information about the company was straightforward (see table 3.1). It is mainly information to be able to contact the person who filled out the questionnaire if questions might rise about the interpretation of the answers given later on in the questionnaire. Furthermore, information was requested about the economic activity of the firm and the size of the firm (expressed by the number of employees).

Table 3.1: Company data

| | |
|---|---|
| Company name | |
| Name | |
| Position in company | |
| Telephone | |
| Email | |
| City | |
| Economic activity | |
| Number of employees | |

*Ad 3: Freight flows, reliability and storage capacity*

In this section information is requested on the freight flows of the company (see table 3.2). Most of the requested information needs no further explanation. The importance of seasonability will be explained. For instance, agricultural products might be transported only in the season that the specific product is harvested. In that specific case, there might be an overlap with the seasonability of expected low water periods. Furthermore, there might be a link between just-in-time-deliveries and the storage capacity. More obvious, there will be a link between both just-in-time-deliveries and storage capacity and the sensitivity of a firm for the occurrence and in particular duration of low water periods.

Based on the information provided by table 3.2, a rather complete overview can be deduced of the most important freight flows of the firm and the firm's sensitivity for the length of low water level periods.

Table 3.2: Freight flows, reliability and storage capacity

| | | |
|---|---|---|
| ***Inputs*** | Most important goods | |
| | Most important origin of goods | |
| | Size goods flows (in tons/year) | |
| | Transport modes used | |
| | Transport routes used | |
| | Importance just-in-time delivery | |
| | Importance seasonability | |
| | Storage capacity (in tons) | |
| | Storage capacity (in days) | |
| ***Outputs*** | Most important goods | |
| | Most important destination of goods | |
| | Size goods flows (in tons/year) | |
| | Transport modes used | |
| | Transport routes used | |
| | Importance just-in-time delivery | |
| | Importance seasonability | |
| | Storage capacity (in tons) | |
| | Storage capacity (in days) | |

*Ad 4: Vessel types in operation*

In this section a variation in questions is made between either firms having their own fleet and firms that use brokers. Firms with an own fleet are directly asked which vessel types they operate, whereas in the latter situation, the firms are asked first if they know which vessel types their chartering broker uses. Furthermore, only firms who operate their own fleet are asked how many vessels of each type they operate.

A second variation in questions is made between firms of which the good flows pass only Ruhrort and firms of which the good flows pass Kaub. Under no circumstances push boats are able to pass Kaub with an economic viable load. Their draught is simply too large. Thus in the questionnaires oriented on good flows passing Kaub, push boats are left out.

Table 3.3 Vessel types in operation by either the firm or broker

| type | Name | tonnage | Y/N | Number in operation |
|---|---|---|---|---|
| ***Dry bulk*** | Gustav Koenigs / Dortmund-Ems | 650-1,000 | | |
| | Johan Welker / Europe / Rhine-Herne | 1,000-1,500 | | |
| | GMS 110 /Large Rhine | 1,500-3,000 | | |
| | GMS 110 / Large Rhine + E-II-Rhine (barge) | 6,000 | | |
| | GMS 135/ Large Rhine | 4,000 | | |
| | Pushboat + 4 E-II-Rhine | 6,400-12,000 | | |
| | Pushboat + 6 E-II-Rhine | 9,600-16,800 | | |
| ***Other (fill in)*** | | | | |
| ***Container*** | Standard (GMS 110) | 208 TEU | | |
| | Large (GMS 135) | 272 TEU | | |
| | Jowi | 425-510 TEU | | |

*Ad 5: Previous experiences with low water events*

In this section the questionnaire becomes more difficult for the firms. First, we asked them at what duration a low water event becomes problematic for their firm.

This question is followed by table 3.4 in which they have to describe their experiences with a low water event in the past.

Only in the questionnaires where shippers make use of brokers the question is asked if they had to pay low water surcharges.

Table 3.4: Experiences with a low water event

| | | | | |
|---|---|---|---|---|
| Year and duration (in days)? | Year | | Duration | |
| Was it impossible to navigate (in days)? | Yes/No | | Duration | |
| Did it result in a decrease in reliability of deliveries? | Yes/No | | Duration | |
| Did it result in a shortage of stock? | Yes/No | | Duration | |
| Did it result in a production shutdown? | Yes/No | | Duration | |
| What is the critical ship capacity still feasible to navigate (in tons or %)? | | | tons | % |
| | | | | |
| | Yes/No | Duration (in days) | For how much tonnage? | At what additional costs? |
| Did you pay low water surcharges? | | | | |
| Did you used additional ship capacity? | | | | |
| Did you used alternative transport modes (train/truck)? | | | | |
| Did you reduce your freight transport (inputs and/or outputs) | | | | |

Next, we asked them if they took adaptation measures after the in table 3.4 described low water event, and, if yes, to describe the adaptation measures and provide an indication of the costs of implementing them.

*Ad 6: Impacts of adaptation measures for future low water events*

In this section of the questionnaire we first had to explain the expected duration of low water events in days at the critical locations Ruhrort and Kaub in the period 2021-2050. To be able to do so, the results of climate and hydrological models of WP1, had to be translated into the average number of days of low water events for the period 2021-2050. Given the fact that in WP1 a wet and a dry scenario were developed, we have an interval of days (the difference in days between the dry and wet scenario). Furthermore, we presented the results for an *average year* in the period 2021-2050, but also more extreme situations that might occur once every 5 years or even once every 10 years are presented. The

low water events last longer in Kaub than in Ruhrort. Here we will show the results for Ruhrort. In the annexes you find the results for Kaub in the German version of the questionnaire.
To make it even more complex, the draught of the vessels is important. The draught varies per ship type and is also depending on the load factor of the ship. We took two critical load factors for each ship type: the average load factor (on average the load factor of a vessel is 78%) and a minimal load factor. When the load factor becomes below this minimum load factor it is economic no longer viable to operate the ship. In practice this implies that a ship will no longer be in operation (no navigation possible, see table 3.5). This minimum load factor varies between 23 and 58% depending of the vessel type.

Table 3.5: Expected low water events in days at ***Ruhrort*** in the period 2021- 2050

| | Average load factor (78%) | | | No navigation possible | | |
|---|---|---|---|---|---|---|
| | Average year | 1 of 5 years | 1 of 10 years | Average year | 1 of 5 years | 1 of 10 years |
| **Gustav Koenigs / Dortmund-Ems**<br>Water level load factor 78%: **2.40m**.<br>Water level min. load factor 58%: **2.00m**. | 0-18 | 12-67 | 23-81 | 0 | 0-4 | 0-27 |
| **Johan Welker / Europe / Rhine-Herne**<br>Water level load factor 78%: **2.60m**.<br>Water level min. load factor 29%: **1.80m.** | 0-22 | 18-81 | 33-95 | 0 | 0 | 0 |
| **GMS110/GMS110 + E-II-Rhine/GMS135**<br>Water level load factor 78%: **3.25m.**<br>Water level min. load factor 23%: **1.80m.** | 55-100 | 113-157 | 117-187 | 0 | 0 | 0 |
| **Push + 4 E-II-Rhine/Push + 6 E-II-Rhine**<br>Water level load factor 78%: **3.55m.**<br>Water level min. load factor 32%: **2.00m.** | 83-154 | 126-206 | 135-229 | 0 | 0-4 | 0-27 |

In table 3.5 you find the results for the critical location Ruhrort. For instance, a Gustav Koenigs vessel has a draught of 2.40m given its average load factor of 78%. Given this specification in an extreme situation that happens once in every 10 years it is unable to pass Ruhrort 23 days a year according the wet scenario but 81 days according to the dry scenario. In the same extreme situation that happens every 10 years it can always pass Ruhrort at its minimum (economic viable) load factor of 58% according the wet scenario, however, when we apply the dry scenario it is unable to pass Ruhrort under this conditions for 27 days.

Important to note already here is that we did realize ourselves it would be difficult for firms to read and understand the information provided in table 3.5. However, this was the only possibility to apply the results of WP1. The only alternative was to apply hypothetical situations as discussed in the literature overview. By adding the results of WP1 we created great added value to the depth of the analysis done so far, at the same time being well aware that we took the risk of making the questionnaire too complicated.

Table 3.5 could only be presented in case of firms operating their own vessels. They are familiar with vessel types and their draught characteristics. However this might not be the case for firms that use chartering brokers for their in land waterway transport.
For them we presented two different tables (see table 3.6 and 3.7). In the first table we present an overview of low water levels and their duration. We did this again for the wet and dry scenario's and for the average year in the period 2021-2050 and the more extreme years that are expected to happen once every 5 or 10 years. The selected water levels, of course, match with the various critical draught values of the vessels presented in table 3.7. If the firm knows which vessels are used by their chartering broker it

could link both tables and read the consequences for the firm. If the firm did not know exactly what vessels are used by its broker, it got at least an impression of the order of magnitude.

Table 3.6: Duration of low water events in the period 2021-2050

| Water level at Ruhrort | Average year | Once every 5 years | Once every 10 years |
|---|---|---|---|
| 1.80 meter | 0 | 0 | 0 |
| 2.00 meter | 0 | 0-4 | 0-27 |
| 2.40 meter | 0-18 | 12-67 | 23-81 |
| 2.60 meter | 0-22 | 18-81 | 33-95 |
| 3.25 meter | 55-100 | 113-157 | 117-187 |
| 3.55 meter | 83-154 | 126-206 | 135-229 |

Table 3.7: Draught of vessels given their load factor

| | Average load factor (78%) | Navigation not viable |
|---|---|---|
| Gustav Koenigs / Dortmund-Ems | 2.40 meter | 2.00 meter |
| Johan Welker / Europe / Rhine-Herne | 2.60 meter | 1.80 meter |
| GMS110/GMS110 + E-II-Rhine/GMS135 | 3.25 meter | 1.80 meter |
| Pushboat + 4 E-II-Rhine/ Pushboat + 6 E-II-Rhine | 3.55 meter | 2.00 meter |

After sketching the low water events as described above, the firms are asked if these results would force them to come up with adaptation measures in the coming years, and, if yes, which of the following adaptation measures seems to be the best solution for the company, which second best and which third best. Of course, they were also asked why they selected those measures as best, second best or third best.

They could either select one of the following six adaptation measures or add another adaptation measure:

- Adaptation fleet: smaller ship;
- Adaptation fleet: lighter ship;
- Larger storage capacity (postponement of transport);
- Alternative transport;
- Shutdown of production process;
- Relocation of production process.

The final part of the questionnaire was probably the most difficult part. The firms were asked to express the impacts of the implementation of the adaptation measures they selected as best, second best, and third best. They were asked to provide as far as possible quantitative figures, for instance in terms of costs or employment. Those figures did not have to be precise but have to express an order of magnitude. If they could not express the impact in a quantitative manner, they were asked to apply the qualitative scale presented in table 3.8.

Table 3.8: Qualitative scale to express impacts adaptation measures

| +++ | ++ | + | 0 | - | -- | --- |
|---|---|---|---|---|---|---|
| Very positive effect | Clear positive effect | Slightly positive effect | Neutral effect | Slightly negative effect | Clear negative effect | Very negative effect |

In table 3.9 we show the impacts of adaptation measures we are interested in. It goes without saying that the criteria are selected in close cooperation with the work in task 2.2. In task 2.2 the impacts of the adaptation measures researched in tasks 2.1.1 – 2.1.4 will be analysed by multi-criteria analysis.

Considering the investment and maintenance costs, the firms are requested to indicate by which stakeholder those costs are made. If it are shared costs, they were asked to express the costs in shares for each stakeholder.

Table 3.9: Impacts of adaptation measures

| | | Best measure | Second best | Third best |
|---|---|---|---|---|
| Costs of implementation | Investment | | | |
| | Who makes investment? | | | |
| | Maintenance | | | |
| | Who bears maintenance costs? | | | |
| Employment | Direct (increase own company) | | | |
| | Indirect (increase suppliers) | | | |
| Environment | Energy consumption (reduction) | | | |
| | Air quality (red. SO2, PM10, NOx) | | | |
| | Water pollution (reduction) | | | |
| | Noise (reduction) | | | |
| | Nature conservation | | | |
| | Use of space (reduction m2) | | | |
| | Transport safety | | | |
| Other effects | Public acceptance | | | |
| | Legal situation | | | |

## 3.2 Response analysis

The first activity was to construct a mailing list of shippers to which the questionnaire could be send. All DST, NEA and VU-FEWEB had a limited network of contacts. Seven of those contacts fitted to the selection criteria, of which three firms filled out the questionnaire.

In March 2011 the European Shipper Council was approached for a list of shippers. Unfortunately, they were unable to provide a list of individual shippers. However, they suggested contacting the Dutch Shipper Association (EVO). EVO was willing to ask a number of its members to cooperate. Three of their members were willing to participate in the research project and indeed filled out the questionnaire.

After consultation of Anja Scholten we decided to apply the same approach as she did rather successfully (response rate 25%). We searched in Google Maps for the email addresses of firms located on industrial sites along the river Rhine (from Ruhrort upstream towards Strasbourg) with an own inland waterway loading dock. This was a time consuming activity resulting in 43 email addresses. In the period 23rd -26th of May, those firms were asked to cooperate in the research project by email, including the English version of the questionnaire[2]. None of those 43 firms responded within two weeks. A next step was to phone those firms to ask them for a specific contact person within the firm. However, four out of five firms disconnected as soon as we approached them in English. We realized that a questionnaire in English might have been the cause of the bad response. Remember that Anja Scholten was quite successful with her - less complicated - questionnaire in German. So DST translated the questionnaire in German and we send the questionnaire to the same 43 firms on the 7th of July. This was well before the vacation season in Germany, starting on the 22nd of July[3]. By the end of July we had received only one questionnaire back from those 43 firms. A rather disappointing result.

Explanations for this poor result might be:

- A poor letter of recommendation;

[2] Unfortunately, the author Frank Bruinsma was seriously ill for over four weeks in the period April-May.

[3] Also the firms of our own networks and the firms supplied by EVO were sent a reminder on the 7th of July.

- The topic is at present not a serious problem for the shippers;
- The scope of the project, 2021-2050, is too far in the future;
- The questionnaire was too complicated;
- The questionnaire was not sent to a specific contact person within the firm.

We don't think the first explanation hold. The letter of recommendation (see annex 1) was checked and approved by the other project partners. Given the experiences in the – recent – past, shippers were confronted with low water levels in 2003 and also 2011 was a relative dry summer. Moreover, the Rhine was blocked in the spring of 2011 by a tanker ship in the Lorelei for several weeks. Although the cause was different, the problems caused by the blockade are similar compared to a long period of low water levels. Nevertheless, shippers may not connect the two events as such.

We think a combination of the last four explanations mentioned, was the cause of the low response rate. Due to the uncertainties in the prediction models, the range of durations of low water levels was rather large for the period 2021-2050. It might have been difficult for shippers to understand the implications for their firm given the large ranges and the time horizon of 2021-2050. Secondly, compared to the questionnaire of Anja Scholten our questionnaire was much more complicated and demanded much more knowledge and time from the shippers. Nevertheless, the questionnaire was checked and approved by our project partners. Finally, it is a disadvantage not knowing the right person within the company to contact. Many e-mail addresses started with info@.... You never know if the person receiving the email is willing to search within the company to find the best person to fill out the questionnaire. They might receive many of such requests to participate in research projects and might delete the email without taking notice of the contents of the request.

Given the low response on previous activities (7 out of 53 questionnaires is a response rate of 13%) , by the end of August we sent the questionnaire by mail to all the 76 branches along the river Rhine and its tributaries of the 46 companies that did not responded yet. This resulted in another two questionnaires in the beginning of September.

Table 3.10: Sent out questionnaires by email

| | Kaub | Ruhrort | Total |
|---|---|---|---|
| Steel & steel construction | 15 | 17 | 32 |
| Energy | 3 | -- | 3 |
| Agriculture | 3 | 1 | 4 |
| Logistics | 2 | 3 | 5 |
| Minerals | 6 | 3 | 9 |
| | 29 | 23 | 53 |

Table 3.11: Final response (email and mail)

| | Kaub | Ruhrort | Total |
|---|---|---|---|
| Steel & steel construction | 2 | 4 | 6 |
| Energy | -- | -- | |
| Agriculture | 1 | -- | 1 |
| Logistics | -- | -- | |
| Minerals | 1 | 1 | 2 |
| | 4 | 5 | 9 |

Overall, we had a response of 9 questionnaire (17%). This is lower than the response of Scholten (2010) with 62 out of 248 (25%), but higher than the response of Jonkeren et al. (2010) with 12 out of 220 (5.5%). In the other studies no response analysis is given. However, in all studies only a limited number of firms participated in the research. It can be concluded that the inland waterway sector is rather difficult to study.

# 4. Results of the questionnaire

The response rate (only 9 firms) is too low for reliable statistical analysis. As a consequence the analysis is qualitative, descriptive. Much attention is given to the confidentiality of the firms that did respond to the questionnaire. This implied that not all information could be used in depth.

## 4.1 Description of the companies

Most of the firms (6 out of 9) are steel or steel construction firms, 2 firms are active in the mineral sector and the final firm is active in the agriculture processing sector (see table 4.1).
We have five firms that are mainly active on the lower Rhine and only have to pass the critical location at Ruhrort. The other four firms are also active on the middle and upper Rhine and for them Kaub is the critical location for their transport flows by barge.
Three firms are owner of the barges they use, the other six are active on the contract or spot market.

Table 4.1: Economic sector, critical location and fleet ownership

| | Ruhrort | | Kaub | |
|---|---|---|---|---|
| | Own fleet | No fleet | Own fleet | No fleet |
| Steel | 1 | 3 | 1 | 1 |
| Minerals | | 1 | | 1 |
| Agriculture | | | 1 | |

## 4.2 Transport modes and storage capacity

Only one firm is solely depending on barges. The other firms use a mix of transport modes (barge, rail, truck, and pipeline). Considering the input flow of goods, in addition to barges, 6 firms use rail, 4 firms use trucks and 1 firm pipelines. Considering the output flow of goods, four firms use a different mix of transport modes. Two firms do not use barges anymore, pipelines are not in use anymore and the truck is used by as many firms as rail (both 6 firms). It can be concluded that due to the processes at the firms, there is a small shift from bulk carriers to product carriers.
Considering storage capacity, four out of nine firms state that the storage capacity of inputs cannot be expressed in days because it depends on the mix of goods available at the plant, this mix in goods differs over time. The firms that did express the storage capacity in days often mention a range of days. Three firms state that the storage capacity of inputs is sufficient for in between 1-2 weeks, one company gives a very wide range from a few days to nearly a month, and the last firm has a storage capacity of nearly 6 weeks. Considering the storage capacity of outputs, the firms are even more insecure. Only three firms provide information: two firms have a storage capacity of 2 weeks and one firm of about 3 weeks.
A final important question is after what duration a low water event becomes problematic. Only four firms were able to answer that question. The answers were all in between 1 and 3 weeks (7, 10, 14, and 21 days). For one firm this was a longer period than its storage capacity (21 versus 14 days of storage capacity), for one firm it was much shorter (7 days versus 40 days of storage capacity). So based on this limited and even contradictory information nothing can be said about a relation between storage capacity and sensitivity for low water duration.

## 4.3 Passed experiences with low water events

When asked if the firm has passed experiences with low water events, all firms indeed had some experiences. Three firms referred to the extreme dry year 2003, but another four firms referred to events that happened in 2011. Two firms didn't make clear which year the low water event happened.

The impacts of low water events on the supply of goods by inland waterways was rather similar for all firms, regardless the economic activity or the critical location to pass. Seven out of eight firms said that it was still possible to navigate during the low water event, however as many firms stated that the reliability in deliveries decreased.

All firms without an own fleet mentioned that they were confronted with low water surcharges (up to 100% of the normal transport costs).

All firms used additional ship capacity and alternative transport modes during the low water events. Only 2 firms reduced their freight flows.

The impact on their stock of goods differed among the firms. Four out of eight firms stated that they experienced a shortage of stock during a previous low water event. This concerned two firms who had to pass Ruhrort and two other firms who had to pass Kaub, so the result seems not related to a specific critical point in the waterway system. However, the shortage of stock has lead to a production shutdown in only one case.

In reply of the question if experiences with low water events have led to adaptation strategies in the past, 5 of the firms say they did not.

Two firms improved their contract with the rail sector. One of them negotiated a complete new long term train contract for approximately 1 million tonnes per year.

Another firm states that it hardly suffers from low water events, but in exceptional cases it will supply its clients from other plants or use trucks for the deliveries.

The final company decided to closely monitor the daily water levels and fully exploit the loading opportunities and accept the risk of demurrage. The related costs are estimated at €50 per day for manpower, the costs of demurrage are hard to estimate.

## 4.4 Adaptation measures on climate change

After showing them the expected impact of climate change on water levels in the period 2021-2050, the firms were asked if the expected future low water events would force them to adjust and take adaptation measures in advance.

Three out of four firms that have to pass the critical location Kaub explicitly state that they will take adaptation measures to cope with the climate change effects as presented to them in the questionnaire. Considering the critical location Ruhrort, only one firm makes this explicit statement and another three firms mention the best adaptation measures. Two steel companies (one that has to pass the critical location Ruhrort and the other Kaub) say that they will not adapt on the presented climate change effects, although the latter mentions the best adaption measures for the firm.

So in total four out of nine firms explicitly state that they will adapt on the presented climate change effects: two will not adapt. Eight firms informed us about the adaptation measures they prefer.

In table 4.2 we give an overview of the preferred adaptation measures. The eight firms mention in total 20 adaptation measures. All firms mention to adapt by using alternative transport modes. For five of them this is the most preferred adaptation strategy. Five adaption measures concern adjustments to the fleet. These result matches with the behaviour of the firms during previous low water events as described in section 4.3. A final often selected adaptation measure is to extend the storage capacity. In section 4.2 we had to conclude that there is no clear relation between storage capacity and sensitivity for low water events. Only one firm states that a production shutdown is the third best adaptation measure. In section 4.3 we saw that indeed one firm has come to a production shutdown during a past low water event.

Table 4.2: Preferred adaptation measures

| | First best | Second best | Third best | *Total* |
|---|---|---|---|---|
| Smaller ship | | 1 | | *1* |
| Lighter ship | 2 | 1 | | *3* |
| Storage capacity | 1 | 2 | 3 | *6* |
| Alternative transport | 5 | 2 | 1 | *8* |
| Shutdown production | | | 1 | *1* |
| Relocation production | | | | |
| Koppelverband | | 1 | | *1* |
| *Total* | *8* | *7* | *5* | *20* |

When we take the critical locations in the waterway system into consideration, we can see a slight preference for adjustments to the fleet in case of Ruhrort and a preference to increase storage capacity in case of Kaub (see table 4.3). However, keep in mind that this is based on a limited number of observations!

Table 4.3: Preferred adaptation measures given the critical location to pass

| | Ruhrort | | | Kaub | | |
|---|---|---|---|---|---|---|
| | First best | Second best | Third best | First best | Second best | Third best |
| Smaller ship | | 1 | | | | |
| Lighter ship | 1 | 1 | | 1 | | |
| Storage capacity | | 1 | 1 | 1 | 1 | 2 |
| Alternative transport | 3 | | 1 | 2 | 2 | |
| Shutdown production | | | | | | 1 |
| Relocation production | | | | | | |
| Koppelverband | | | | | 1 | |

Table 4.4: Preferred adaptation measures given economic activity

| | Steel | | | Minerals and agriculture | | |
|---|---|---|---|---|---|---|
| | First best | Second best | Third best | First best | Second best | Third best |
| Smaller ship | | 1 | | | | |
| Lighter ship | 2 | 1 | | | | |
| Storage capacity | | 2 | 2 | 1 | | 1 |
| Alternative transport | 3 | 1 | 1 | 2 | 1 | |
| Shutdown production | | | 1 | | | |
| Relocation production | | | | | | |
| Koppelverband | | | | | 1 | |

When we take the economic activity into account (table 4.4), the steel and steel construction sector has a slight preference for adaptation measures considering the fleet. Remarkable is that firms that own a fleet all mention alternative transport as the first best adaptation measure, an adjustment to their fleet as the second best option, and an adjustment at the firm (either extension of the storage capacity or production shutdown) as the third best solution (see table 4.5). One would expect that firms that own their fleet would try to adjust their fleet so it can be used as economically sufficient as possible.

Table 4.5: Preferred adaptation measures given the ownership of the fleet

| | Own fleet | | | No fleet | | |
|---|---|---|---|---|---|---|
| | First best | Second best | Third best | First best | Second best | Third best |
| Smaller ship | | | | | 1 | |
| Lighter ship | | 1 | | 2 | | |
| Storage capacity | | 1 | 2 | 1 | 1 | 1 |
| Alternative transport | 3 | | | 2 | 2 | 1 |
| Shutdown production | | | 1 | | | |
| Relocation production | | | | | | |
| Koppelverband | | 1 | | | | |

## 4.5 Impacts of adaptation measures

Finally, we asked the firms to qualitatively score the impacts of the preferred adaptation measures on their relevance for society. This was obviously the most difficult part of the questionnaire and we received only limited, incomplete response in case of 11 adaptation measures: 5 concerning the shift towards alternative transport modes (table 4.6); and both 3 concerning increasing storage capacity (table 4.7) and adjustments to the fleet (table 4.8).

It is rather surprising to see that the firms have no clear idea about the costs of implementation in case of a shift in modal transport (table 4.6). Nevertheless, they know that their transport costs will increase. They do think it might lead to a decrease in own employment, but this seems to be compensated by an increase in employment at suppliers of transport services. The environmental impact is estimated to be negative or neutral. The impact on transport safety leaves room for discussion.

In case of an increase in storage capacity, the firms say that they have to do the investment themselves (table 4.7). On the other hand you should expect that firm would indicate a negative impact on the use of space. Extension of the storage capacity implies an increasing pressure on land. However, 2 out of 3 firms score the impact on land use neutral.

The most consistent answers were given considering the impacts of adjusting the fleet (table 4.8). The fleet owner bears the investment costs. In case of a firm with an own fleet it will be the firm itself. Lighter ships will have no impact on employment. If you have smaller ships, you need more ships so an increase in employment. When you will change from single ships to koppelverband you will need less ships and thus less employment. The same reasoning can be applied for energy consumption. Most of the other environmental impacts are expected to be marginal.

Table 4.6: Impacts of the adaptation towards alternative transport modes

| | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Costs of implementation | Investment | 0 | N | | - | |
| | Who makes investment? | | | | Firm | |
| | Maintenance | 0 | N | | n/a | |
| | Who bears maintenance costs? | | | | | |
| Employment | Direct (increase own company) | 0 | N | | - | - |
| | Indirect (increase suppliers) | ++ | Y | | - | + |
| Environment | Energy consumption (reduction) | - | N | + | - | -- |
| | Air quality (red. SO2, PM10, NOx) | 0 | N | + | - | -- |
| | Water pollution (reduction) | 0 | | 0 | 0 | |
| | Noise (reduction) | - | N | - | 0 | -- |
| | Nature conservation | 0 | | - | 0 | - |
| | Use of space (reduction m2) | 0 | N | 0 | 0 | |
| | Transport safety | ++ | | ++ | 0 | -- |
| Other effects | Public acceptance | -- | | + | 0 | -- |
| | Legal situation | 0 | | + | 0 | |

Table 4.7: Impacts of the adaptation by increasing the storage capacity

| | | 1 | 2 | 3 |
|---|---|---|---|---|
| Costs of implementation | Investment | -- | Y | -- |
| | Who makes investment? | Firm | Supplier | Firm |
| | Maintenance | -- | N | n/a |
| | Who bears maintenance costs? | Firm | N | |
| Employment | Direct (increase own company) | 0 | N | 0 |
| | Indirect (increase suppliers) | ++ | Y | - |
| Environment | Energy consumption (reduction) | -- | Y | 0 |
| | Air quality (red. SO2, PM10, NOx) | 0 | Y | 0 |
| | Water pollution (reduction) | 0 | | 0 |
| | Noise (reduction) | - | Y | 0 |
| | Nature conservation | -- | | 0 |
| | Use of space (reduction m2) | 0 | N | 0 |
| | Transport safety | + | | 0 |
| Other effects | Public acceptance | - | | 0 |
| | Legal situation | 0 | | 0 |

Table 4.8: Impacts of the adaptation by adjusting the fleet

| | | lighter | smaller | koppelverband |
|---|---|---|---|---|
| Costs of implementation | Investment | | | -/-- |
| | Who makes investment? | Fleet owner | Fleet owner | Firm |
| | Maintenance | | | n/a |
| | Who bears maintenance costs? | | | |
| Employment | Direct (increase own company) | 0 | 0 | 0 |
| | Indirect (increase suppliers) | 0 | + | - |
| Environment | Energy consumption (reduction) | + | - | 0 |
| | Air quality (red. SO2, PM10, NOx) | + | 0 | 0 |
| | Water pollution (reduction) | | | 0 |
| | Noise (reduction) | 0 | 0 | 0 |
| | Nature conservation | | | 0 |
| | Use of space (reduction m2) | | | 0 |
| | Transport safety | 0 | 0 | 0 |
| Other effects | Public acceptance | 0 | 0 | 0 |
| | Legal situation | | | 0 |

# 5. Conclusions and recommendations

Shippers act as all other economic agents: they invest in adaptation measures when the costs of not adapting outweigh the costs of the adaptation measures. The main problem for inland waterway transport is that at present the annual variation of low water events is already large and it's unclear to what extent climate change influences the annual variation. Extreme climate scenarios, such as KNMI W+, predict low water events such as happened in 2003 nearly on a yearly basis around the year 2050.

ECCONET applies more moderate climate scenarios to predict the incidence of low water events around 2050. Our findings, using a variety of climate and hydrological models, show that the incidence of low water and its relative variability hardly differs from the present situation. An increased tendency for low water events can only be proved for the far future, which is around 2100. This illustrates that the uncertainty of the future pattern of low water events is big and probably too big to convince shippers to adapt.

Our own experience, on the ECCONET workshop in Amsterdam, showed that the IWT-sector reacted quite relieved when they saw the ECCONET predictions of water levels around the year 2050. Or as one of the participants formulated it: "the climatological/hydrological study .... of ECCONET .... has shown that effect on transport conditions will be relatively low, and definitely smaller than the logistic changes the sector is facing". Their focus is on keeping an eye on logistic changes and not so much climate change.

To analyze the adaptive behaviour of shippers we approached 53 shippers with in total 76 branches located along the river Rhine and its tributaries that use inland waterway transport. In the period May-August 2011, we sent out three rounds questionnaires in English and German both by email and post. The final response was 9 questionnaires or a response rate of 17%. This is rather low, but not uncommon in this sector. There have been only few studies known by us that focussed on the IWT-sector in which questionnaires are applied. Only 2 of them mention their response rate: Scholten (2010) realised a response rate of 25% (62 out of 247), Jonkeren et al. 5,5% (12 out of 220).
In the questionnaire, apart from some basic information about the company, the following four topics were questioned:

- Transport modes and storage capacity
- Passed experiences with low water events
- Adaptation measures on climate change
- Impacts of adaptation measures

## 5.1 Transport modes and storage capacity

Most firms in our questionnaire use a mix of transport modes to organise its good flows. Only one firm is solely dependent on IWT. IWT is in particular used for the delivery of inputs. For the outflow of goods the modal share of IWT is smaller. This pattern of use of IWT is also found in the studies of Scholten (2010) and Jonkeren et al. (2010).
Considering the storage capacity the range of answers was rather wide. Important to note was that five companies stated that the storage capacity for inputs depends of the mix of goods. This mix might vary over the year due to seasonality. For outputs, six out of nine firms stated that their storage capacity

depends on the mix of goods. The firms that provided information about their storage capacity mentioned durations between 1 and 2 weeks, only one firm has a storage capacity for inputs of six weeks.

In her study among 64 shippers, Scholten (2010) finds that 42% of the shippers have a stock of inputs of at most one week, 25% for a period of one to two weeks, and 32% for over two weeks. Unfortunately, the stock of inputs is hard to compare with the storage capacity. The storage capacity might be underutilised by the available stock of inputs.

Most important, however, is that both our study and the study Jonkeren et al. (2010) show no clear relation between the available storage capacity and the time it takes before a low water event becomes problematic. In other words, storage capacity gives no clear hint of the vulnerability of an IWT dependent shipper for low water events. This makes it more complex to understand to which extent the extension of the storage capacity can be seen as an adaptation measure for future low water events due to climate change. On the other hand, Scholten (2010) does find a significant relation between the duration a firm can produce without deliveries and the vulnerability to extreme event[4]. However, as stated before, the available stock is something different than the storage capacity. It seems that much firms underutilise their storage capacity (large stocks imply additional capital costs).

Jonkeren et al. (2010) asked the shippers if they were planning to invest in additional storage capacity. Three out of twelve were considering additional storage capacity. However, only one of them did experience problems related to the low water event of 2003. Thus, most probably, the other two firms have other reasons than the occurrence of low water events to consider the extension of their storage capacity. Nevertheless, both in the study of Jonkeren et al. (2010) as in our study we find that in particular firms located upstream the river Rhine are investigating the extension of storage capacity.

In addition, Scholten (2010) finds that shippers see the extension of the storage capacity as a final adaptation measure due to the high costs. Also Jonkeren and Rietveld (2009b) find that extension of the storage capacity is only a solution if the investment costs are outweighed by the increase in transportation costs. However, the future transportation costs are difficult to assess given the uncertainty about the predictions of future low water events. This makes it difficult for shippers to make a well-considered investment decision.

## 5.2 Passed experiences with low water events

In our study all firms had experiences with low water events in the past. The same holds for the research of Rietveld & Jonkeren (2009b). In Jonkeren et al. (2010) eight out of twelve shippers experienced problems in 2003. However, in the study of Scholten (2010) only a small majority (53%) of the firms experienced problems with low water events. It might be that our study and the study of Jonkeren & Rietveld are biased due to our low response rates: only firms that have faced problems responded. However, in our study some firms referred to the low water event in spring 2011 which happened after the study of Scholten was held. Moreover, in the Amsterdam workshop it was stated that increased transport costs during low water events (either due to modal shift or low water surcharges) is no problem in periods of economic growth such as was the case during the long lasting low water event in 2003, but becomes a serious problem in periods of economic decline such as in 2011. This might imply that the low water event in 2011 has had a bigger impact on the financial situation of shippers, than the much longer lasting low water event in 2003.

[4] This was the only hypothesis for which a significant relation was found. Other relations such as the impact of frequency and regularity of deliveries on the vulnerability for extreme events could not be proven significant. The same holds for vessel size and vulnerability and access to transport modes and reduced vulnerability.

In our study most firms stated that inland navigation remained possible, however the reliability of deliveries decreased, the transportation costs increased, additional ship capacity was hired, and additional transport modes were used. Four out of eight shippers experienced a shortage of stock, of which one led to a production shutdown. Jonkeren et al. (2010) found similar responses. The shippers stated to have paid the increased transport prices, they reduced production and used alternative transport.

In our study, three out of nine firms prepared themselves against future events by taking adaptation measures: two improved their contract with the rail sector, and the third decided to closely monitor the daily water levels to be able to optimize the loading factor.

## 5.3 Adaptation measures on climate change

In our research we asked the shippers if the expected low water events around the year 2050 as predicted by the Ecconet project in WP1 would force them to adjust and take adaptation measures in advance. Four out of nine firms said they would adjust. Scholten (2010) found much smaller figures: 69% of the firms expected impacts of climate change on the occurrence of extreme (low water) events in the future. Only a quarter of them already took adaptive actions, 17% prepare actions, but the majority (59%) have no intention to undertake action. The adaptation measures mentioned were extending storage capacity and modal shift. The difference between both studies can be explained by the information provided to the shippers. We gave the shippers information about the occurrence of low water events around 2050 and Scholten did not.

In our research, eight firms mentioned their first, second and third best adaptation measures to cope with low water events. All eight shippers mentioned the use of alternative transport, most of them mentioned it as the first best solution. Adaptation of the storage capacity and the fleet were mentioned six and five times, respectively. However, adaption of the fleet was mentioned always as the first (2) or second (3) best measure, whereas expansion of the storage capacity was mentioned three times as the third best solution. Production shutdown was mentioned once, relocation of the firm was not mentioned as an expected adaptation measure. It can be concluded that there seems to be a clear preference for; first: alternative transport, second: adaptation of the fleet, and third: extension of the storage capacity.

In the Amsterdam workshop this ranking of the preferred adaptation measures was confirmed by the stakeholders: shippers, operator and representatives of the IWT sector. Although the literature reveals that there is limited additional capacity available on rail and road, for most shippers the first best adaptation measure is to use alternative modes of transport. The advantage of modal shift is that it can be organised in a relative short time. The second best measure is adaptation of the fleet. Of course this will take much longer because barges are in service for at least 40 years, so it takes a long time before the fleet is adjusted. The stakeholders were also unanimous about who the costs of such an operation would bear: the operator.

It is interesting to compare the stated preference on adaptation measures with information out of practice. NEA (2010) asked 74 ship owners if they seriously considered alternative transport during the blockade of the Rhine. The majority of 43 firms did not consider alternative transport. Their main reasons were: uncertainty about duration, too expensive, and no capacity available. All those arguments also would hold in case of a low water event. Of the 31 companies who did seriously consider alternative transport, 22 made no use of alternative transport in the end. NEA also concludes that it appears to be that future accidents or uncertainty caused by low water events is not something that is seriously considered as a reason for more cooperation with other modes to be more flexible and better prepared. A vast majority (93%) indicates that future cooperation is not considered.

## 5.4 Impacts of adaptation measures

None of the studies found in the literature survey researched the societal impacts of adaptation measures and also our study fails to a large extend to do so. Some studies doe estimate the welfare effects of low water events in general but not of adaptation measures. One exception is made by Jonkeren et al. (2010), who demonstrated that the annual welfare effect of an optimisation of the operational hours of the fleet is positive in case of the KNMI W+ scenario around 2050.

## 5.5 General conclusion and recommendation

Based on own research and the literature review, we can conclude that the first - short term - adaptation steps will be taken within the shippers direct handling space: either the production process or the existing transport arrangements.

Within the production process shippers have several opportunities to interfere/adapt: 1) change in the composition of inputs, 2) further refinement/processing of the products, 3) temporary reduction of production, etc. Within the existing transport arrangements even a larger number of - short term - opportunities are open: 1) hiring extra capacity on the inland waterway spot market, 2) optimization of the utilization of the fleet, 3) postponement of inland waterway transport, 4) paying the low water surcharges, 5) modal shift, etc.

Remember that only few firms are solely depending on inland waterways, most of the firms also make use of rail and/or road transport. They can use their existing contacts with those rail and road operators for - minor - changes within the existing capacity constraints of those modes.

The above solutions are all short term and do not hold when low water events have a large duration such as happened in 2003 or become a structural phenomenon. In such cases more structural adaptation measures must be undertaken.

From both the literature review and our own research it can be concluded that the use of alternative transport modes, adaptation of the fleet (ship owners), and extension of the storage capacity, are the most preferred adaptation measures amongst shippers.

The use of alternative transport modes was considered to be the best solution, when it can be realised at short term and at moderate cost. Limits in capacity of other modes and inflexibility of (mainly) railway contracts were serious impediments to this option. Road transport is only an option for relatively short distances and for a limited amount of goods. Adaptation of the fleet will take much time, but is still preferred above extension of the storage capacity. Extension of the storage capacity implies 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 (see section 2.2). Nevertheless, the willingness of shippers to take adaptation measures to prevent such cost appears 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 rather moderate changes for the 'near future' (until 2050) and too much uncertainties for the IWT-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 is spread among the stakeholders: shippers, operators, and in some cases even insurers. Of course each stakeholder will try to pass his costs on to his 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.

Given the above analysis we can only recommend not to expect too much adaptive behaviour of shippers for the 'near future'. 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.

# 6. References:

Bfg (2006), *Niedrigwasserperiode 2003 in Deutschland: Ursachen – Wirkungen – Folgen*, Bundesanstalt für Gewässerkunde, Koblenz

Jonkeren, O. (2009), *Adaptation to climate change in inland waterway transport*, PhD Thesis, Vrije Universiteit, Amsterdam.

Jonkeren, O. & P. Rietveld (2009a), *Impacts of low and high water levels on inland waterway transport*, VU University, Amsterdam.

Jonkeren, O. & P. Rietveld (2009b), *Impacts of low and high water levels on reliability and transport costs in inland waterway transport*, VU University, Amsterdam.

Jonkeren, O., P. Rietveld & J. van Ommeren (2007), Climate change and inland waterway transport: welfare effects of low water levels on the River Rhine, *Journal of Transport Economics and Policy*, Vol. 41, pp 387-411.

Jonkeren, O., P. Rietveld & A.van der Toorn (2010), *Economic analysis of adaptation measures to climate change*, VU University, Amsterdam.

Krekt, A.H., T.J. van der Laan, R.A.E van der Meer, B. Turpijn, O.E. Jonkeren, A. van der Toorn, E. Mosselman, J. van Meijeren & T. Groen (2011), *Climate Change and inland waterway transport: impacts on the sector, the Port of Rotterdam and potential solutions*, Knowledge for Climate, www.knowledgeforclimate.org.

Min. V&W, RWS, RIZA, Arcadis, HKV, KIWA, Korbee&Hovelynck, D. Klopstra, R. Versteeg & T. Kroon (2005), *Droogtestudie Nederland: Aard, ernst en omvang van watertekorten in Nederland*, Ministerie van Verkeer en Waterstaat, Den Haag

NEA (2011), *Closure of River Rhine at the Lorelei rock: estimate of impact and allocation of damage*, NEA, Zoetermeer

Nomden, E. & W. van Deursen (1999), *Invloed van klimaatverandering op de binnenvaart*, Carthago Consultancy, Rotterdam.

Scholten A. (2010), *Massenguttransport auf dem Rhein vor dem Hintergrund des Klimawandels*, Würzburger Geographische Arbeiten, Heft 104, Universität Würzburg, Würzburg.

Scholten, A. & B. Rothstein (2009), Critical influencing variables for the economic sector depending on bulk goods, in: *Conference proceeding KLIWAS Impacts of climate change on waterways and navigation in Germany*, Federal Ministry of Transport, Building and Urban Development, Bonn, pp 83-86.

Scholten, A. & B. Rothstein & R. Baumhauer (2010), Critical parameters for mass-cargo affine industries due to climate change in Germany: Impact of low water events on industry and possible adaptation measures, In: W. Leal Filho (ed.), *Social, economic and political aspects of Climate Change*, Springer Verlag, Heidelberg, pp. 267-287.

# Annex 1: Letter of recommendation (English)

Dear madam/sir,

The European Commission want to support sustainable transport in Europe. Inland waterway transport is the most sustainable way of transport. Therefore, the EU aims to achieve a shift from road transport into the direction of inland waterways. However, the inland waterway system is not always reliable due to low water levels. In the light of the expected climate change, the EU want to develop new policies to improve the navigation conditions and make the Rhine-Danube waterway system more robust/reliable.

To get more knowledge about climate change and its impacts on the navigation conditions, DG TREN of the European Commission is funding the research project ECCONET. In this project the navigation conditions in the near future (2021-2050) are assessed, as projected by current climate models. Next, adaptation strategies for coping with possible climate change effects on inland waterway transport will be identified. Adaptation measures can be taken on several levels; the inland waterway fleet, the inland waterway infrastructure, and measures to be taken by shippers.

With this email I ask you for your cooperation in the research on the inventory of adaptation measures and strategies feasible for shippers.

With your cooperation you help us to inform the EU about how the EU can improve the navigation conditions on the Rhine-Danube waterway system.

My request to you is the following. I would like to ask you to participate in the research by filling out an questionnaire. I would like to ask you to pass this request to the person within your company who is best informed about the firms' transport flows. Please ask him to contact me by email so I can send him/her the questionnaire.

I expect it will take about 20 at most 30 minutes to complete the questionnaire. It goes without saying that all information stays confidential; no statements will be made about individual firms.

For more information about the ECCONET project, I refer to our first newsletter: www.ecconet.eu/news/ECCONET_newsletter1.pdf

Please feel free to contact me for further information.

Many thanks in advance for your cooperation,

Best regards,

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# Annex 2: Letter of recommendation (German)

Sehr geehrte Damen und Herren,

Hatte Ihr Unternehmen in den letzten Jahren Transportprobleme aufgrund von Niedrigwasser auf dem Rhein? Wenn Sie diese Frage bejahen, ist das Projekt ECCONET sicher auch für Sie von Interesse.
Die EU will Transportverlagerungen von der Straße zur Binnenschifffahrt unterstützen. Allerdings kann die Zuverlässigkeit und Wettbewerbsfähigkeit der Binnenschifffahrt vor dem Hintergrund des zu erwartenden Klimawandels durch erwartete häufigere Niedrigwasserperioden beeinträchtigt werden. Vor diesem Hintergrund sollen Anpassungsmaßnahmen entwickelt werden, um die Wettbewerbsfähigkeit und Zuverlässigkeit der Binnenschifffahrt auch zukünftig zu gewährleisten.
Um mehr über den Klimawandel und seine Auswirkungen auf die Binnenschifffahrt zu erfahren, fördert die Europäische Kommission das Projekt ECCONET. Dieses Vorhaben bewertet die Klima- und Wasserstandsbedingungen, wie sie aus heutiger Sicht für die kommenden Jahrzehnte (2021 – 2050) erwartet werden. Im Weiteren sollen Anpassungsmaßnahmen identifiziert und bewertet werden, mit deren Hilfe mögliche Auswirkungen des Klimawandels auf die Binnenschifffahrt kompensiert werden können. Diese Maßnahmen haben verschiedene Ansatzpunkte: die Binnenschiffsflotte, die Wasserstraßeninfrastruktur und Maßnahmen der Verlader.
Durch das Ausfüllen des beigefügten Fragenbogens unterstützen Sie uns bei der Identifikation und Bewertung relevanter Anpassungsmaßnahmen und -strategien.
Wir möchten Sie deshalb bitten, den Fragebogen an den/die Mitarbeiter(in) weiterzuleiten, der/die in Ihrem Unternehmen mit Transportfragen befasst ist. Im Gegenzug informieren wir Sie gerne über die Ergebnisse des Projekts, wenn Sie dies wünschen.
Als Anlage erhalten Sie zwei Versionen des Fragenbogens: Die Version A ist für Unternehmen mit einer eigenen Binnenschiffsflotte, die Version B richtet sich an Firmen, die die Hilfe von Charterern (entweder auf dem Spot-Markt oder über Verträge) in Anspruch nehmen, um die Binnenschiffstransporte zu organisieren. Bitte wählen Sie den für Ihr Haus geeigneten Fragebogen aus.
Das Ausfüllen wird ca. 20-30 Minuten dauern. Bei Rückfragen sprechen Sie uns bitte an (Tel. oder e-mail, s.u.), wir beantworten Ihre Fragen gerne. Im Zweifelsfall senden Sie uns bitte auch nur teilweise ausgefüllte Bögen zurück; auch diese helfen uns.
**Selbstverständlich werden alle Informationen vertraulich behandelt; es werden keine Daten von einzelnen Unternehmen veröffentlicht.**
Wir wären Ihnen sehr dankbar, wenn Sie uns den Fragebogen bis Freitag, den 16. September 2011 auf dem Postweg zurücksenden könnten. Geben Sie bitte an, ob Sie Informationen über die Projektergebnisse wünschen!
Nähere Informationen über das ECCONET Projekt finden Sie unter: **www.ecconet.eu/news/ECCONET_newsletter1.pdf.**

Besten Dank im Voraus für Ihre Unterstützung!

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# Annex 3: The questionnaire for shippers with an own fleet (German)

## Version A: Mögliche Anpassungsmaßnahmen an den Klimawandel und an veränderte Wasserstandsbedingungen – aus Sicht von Verladern mit eigener Flotte

**Einleitung**

Dieser Fragebogen ist Teil des ECCONET-Projektes, das durch die Europäische Kommission (DG-TREN) gefördert und von einem interdisziplinären Konsortium aus Meteorologen, Wirtschaftswissenschaftlern und Transportexperten durchgeführt wird. Im Mittelpunkt des Projektes stehen die Klima- und Wasserstandsbedingungen der kommenden Jahrzehnte (2021-2050): Generell wird erwartet, dass der Klimawandel zum einen stärkere Regenfälle mit sich bringen könnte, die zu häufigeren Hochwasserperioden führen. Auf der anderen Seite werden häufigere und längere Trockenperioden und in deren Folge intensivere Niedrigwasserphasen für die Binnenschifffahrt erwartet.

Im Rahmen des Projektes sollen Strategien für eine Anpassung an mögliche Klimawirkungen für die Binnenschifffahrt identifiziert und im Hinblick auf ihre Anwendbarkeit, Realisierung und Kosteneffekte bewertet werden. Dabei werden Anpassungsmaßnahmen unterschiedlicher Art berücksichtigt: bezogen auf die Binnenschiffsflotte, die Wasserstraßeninfrastruktur und Maßnahmen der Verlader. Dieser Fragebogen ist Teil der Bestandsaufnahme, um Maßnahmen der Verlader zu identifizieren.

**Was haben Sie zu erwarten?**

Sind Niedrigwasserstände auf dem Rhein ein Problem für Ihr Unternehmen? Falls Sie mit ‚ja' antworten, betrifft Sie diese Umfrage. Das Projekt zielt darauf ab, Strategien zu entwickeln, die die Zuverlässigkeit der Binnenschifffahrt auch bei veränderten Klima- und Abflussbedingungen zu gewährleisten. Deshalb ist es wichtig, einen Einblick zu erhalten in die Probleme der Niedrigwasserstände und in Möglichkeiten, die Binnenschifffahrt anzupassen. Durch Ausfüllen dieses Fragebogens helfen Sie mit, die Chancen hierfür zu verbessern.

**Anleitung zum Ausfüllen des Fragenbogens**

Der Fragenbogen ist folgendermaßen aufgebaut:

1. Firmeninformationen
2. Informationen über Ladungsströme
3. Flotteninformationen
4. Wirkungen von Anpassungsmaßnahmen

Wenn wir um die Angabe von Zahlen bitten, z.B. Anzahl der Mitarbeiter, Tonnen, Kosten, Lagermengen, etc. reichen uns Schätzungen der Größenordnung.

**Alle Informationen werden selbstverständlich streng vertraulich behandelt!**

Für Fragen oder weitere Informationen steht Ihnen Frank Bruinsma zur Verfügung:
**+31/205986096** oder email: **f.r.bruinsma@vu.nl**

## 1. Firmendaten

| | |
|---|---|
| Firmenname | |
| Kontaktperson | |
| Position | |
| Telefon | |
| E-Mail | |
| Ort | |
| Tätigkeit des Untern., (z.B. Stahlproduktion) | |
| Anzahl Mitarbeiter | |

## 2. Ladungsströme, Zuverlässigkeit und Lagerkapazität

Bitte ergänzen Sie folgende Angaben für Ihr Unternehmen:

| | | |
|---|---|---|
| ***Eingang*** | wichtigste Güter | |
| | Herkunft wichtigster Güter | |
| | Größe Ladungsströme (t/a) | |
| | eingesetzte Verkehrsträger | |
| | genutzte Transportrelationen | |
| | Wichtigkeit 'just-in-time' Lieferung | |
| | jahreszeitliche Bedeutung | |
| | Lagerkapazität (t) | |
| | Lagerkapazität (in Tagen) | |
| ***Ausgang*** | wichtigste Güter | |
| | Bestimmungsort für wichtigste Güter | |
| | Größe Ladungsströme (t/a) | |
| | eingesetzte Verkehrsträger | |
| | genutzte Transportrelationen | |
| | Wichtigkeit 'just-in-time' Lieferung | |
| | jahreszeitliche Bedeutung | |
| | Lagerkapazität (t) | |
| | Lagerkapazität (in Tagen) | |

## 3. Schiffstypen im Einsatz

| Typ | Name | Tonnage | J/N | Anzahl im Einsatz |
|---|---|---|---|---|
| ***Trockengut bzw. Massengut*** | Gustav Koenigs | 650-1.000 | | |
| | Johan Welker (Europaschiff) | 1.000-1.500 | | |
| | GMS 110m | 1.500-3.000 | | |
| | Verband: GMS 110m + Europa-II-Leichter | 6.000 | | |
| | GMS 135m | 4.000 | | |
| ***Sonstige** (bitte ausfüllen)* | | | | |
| ***Container*** | Standard (GMS 110) | 208 TEU | | |
| | Groß (GMS 135) | 272 TEU | | |
| | Jowi | 425-510 TEU | | |

## 4. Erfahrungen mit Niedrigwasserphasen

Ab welchem Zeitrahmen wird eine Niedrigwasserphase für Ihr Unternehmen problematisch?
(Bitte Zeitangabe in Tagen, Wochen, Monaten) _______________ Tage/Wochen/Monate.

Niedrigwasserphasen variieren in ihrer Dauer: in manchen Jahren kommen kaum Niedrigwassertage vor, in anderen sind es besonders viele (zum Beispiel im Jahr 2003). Können Sie Ihre Erfahrungen mit einer Niedrigwasserphase in der Vergangenheit beschreiben, die für Sie ein Problem darstellte!

| ***Erfahrungen mit einer problematischen Niedrigwasserphase*** | | | | |
|---|---|---|---|---|
| Jahr und Dauer (in Tagen) | Jahr | | Dauer | |
| Konnten Sie fahren? (Dauer in Tagen) | ja/nein | | Dauer | |
| Führte das Niedrigwasser zu einer Reduzierung der Zuverlässigkeit bei den Lieferungen? | ja/nein | | Dauer | |
| Führte es zu einer Verknappung der Lagermenge? | ja/nein | | Dauer | |
| Führte es zu einem Produktionsausfall? | ja/nein | | Dauer | |
| Mit welchen kritischen Auslastungsgrad des Schiffes konnte noch gefahren werden? (in t oder %) | | | t | % |

| | ja/nein | Dauer (in Tagen) | Mit welcher Tonnage? | Mit welchen zusätzl. Kosten? |
|---|---|---|---|---|
| Haben Sie zusätzlichen Schiffsraum eingesetzt? | | | | |
| Haben Sie alternative Verkehrsträger eingesetzt? (Bahn/LKW) | | | | |
| Haben Sie Ihren Gütertransport reduziert (Eingang und/oder Ausgang) | | | | |

Haben Sie nach diesem von Ihnen beschriebenen Niedrigwasserereignis Anpassungsmaßnahmen eingeführt? JA NEIN

Falls ja, können Sie diese Maßnahmen beschreiben und die geschätzten Kosten für die Einführung dieser Maßnahmen angeben.

| | Beschreibung der Anpassungsmaßnahme | Grobe Kostenschätzung für die Einführung |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |

## 5. Wirkung von Anpassungsmaßnahmen

In der folgenden Tabelle finden Sie für verschiedene Schiffstypen die Folgen der erwarteten Klima- und Abflusswirkungen in Bezug auf die Dauer der Niedrigwasserphasen zwischen 2021 und 2050 in Kaub. Kaub kann als bestimmender Pegel für den Oberrhein angesehen werden. Dort sind bei einem vorgegebenen Tiefgang des Schiffes und einer Kielfreiheit von 30 cm zwischen Schiffsboden und Flussbett die Anzahl der Tage mit einem Niedrigwasser unterhalb des Grenzwertes angegeben, bei dem Schiffe zu 78 % beladen werden können. (78 % ist der durchschnittliche Auslastungsgrad für Binnenschiffe im Zeitraum 1984-2004.) Dabei wird der minimale Auslastungsgrad pro Schiffstyp durch Betrachtung der Auslastungsgrade pro Schiffstyp während der vorhergegangenen Niedrigwasserperioden extrahiert. Wird dieser Grenzwert unterschritten, ist kein Schiffsbetrieb mehr möglich. Für den Zeitraum 2021-2050 finden Sie die Werte für das „Durchschnittsjahr" in der ersten Spalte. Die zweite Spalte enthält die Anzahl der Tage, die einmal in 5 Jahren auftritt. Schließlich finden Sie in Spalte 3 ein Ereignis, dass einmal in 10 Jahren vorkommt. Die Spanne wird durch die Differenz zwischen den trockenen und nassen Klimaszenarien abgebildet.

Erwartetes Niedrigwasser (in Tagen) am Pegel Kaub im Zeitraum 2021-2050

| | durchschnittl. Auslastungsgrad (78%) | | | kein Schiffsbetrieb möglich | | |
|---|---|---|---|---|---|---|
| | Durch-schnitt/ Jahr | einmal alle 5 Jahre | einmal alle 10 Jahre | Durch-schnitt/ Jahr | einmal alle 5 Jahre | einmal alle 10 Jahre |
| **Gustav Koenigs**<br>Wasserstand Auslastungsgrad 78%: **2,40m**<br>Wasserstand min. Auslastungsgr 58%: **2.00m** | 105-136 | 133-204 | 145-235 | 1-29 | 26-80 | 36-122 |
| **Johan Welker (Europaschiff)**<br>Wasserstand Auslastungsgrad 78%: **2,60m**<br>Wasserstand min. Auslastungsgr 29%: **1,80m** | 143-216 | 182-260 | 195-308 | 0-6 | 9-55 | 23-74 |
| **GMS110 bzw. GMS 135 / Verband GMS110 + E-II-Leichter**<br>Wasserstand Auslastungsgrad 78%: **3,25m**<br>Wasserstand min. Auslastungsgr 23%: **1,80m** | 292-324 | 307-365 | 319-365 | 0-6 | 9-55 | 23-74 |

Veranlassen die oben skizzierten Werte Sie dazu, in den nächsten Jahren Anpassungsmaßnahmen einzuleiten?

JA NEIN

Wenn ja, können die folgenden Maßnahmen implementiert werden?

1. Anpassung Flotte: kleinere Schiffe
2. Anpassung Flotte: leichtere Schiffe
3. größere Lagerkapazitäten (Verschiebung des Transportes)
4. alternativer Verkehrsträger
5. Unterbrechung des Produktionsprozesses
6. Verlagerung des Produktionsprozesses
7. andere Anpassungsmaßnahmen und zwar ...........

Welche Anpassungsmaßnahme ist für Ihr Unternehmen die erste Wahl, welche die zweite und welche die dritte?

| | Maßnahme | Grund für Wahl als beste, zweitbeste oder drittbeste Lösung |
|---|---|---|
| beste Anpassungsmaßnahme | | |
| zweitbeste Anpassungsmaßnahme | | |
| drittbeste Anpassungsmaßnahme | | |

Die Tabelle auf der nächsten Seite beschreibt die Auswirkungen von Anpassungsmaßnahmen. Bitte füllen Sie die erwarteten Wirkungen der von Ihnen ausgewählten Anpassungsmaßnahmen so weit wie möglich aus. Verwenden Sie bitte möglichst quantitative Werte, z.B. Kosten oder die Anzahl der Arbeitsplätze. Die Zahlen müssen nicht präzise sein, sondern nur eine Größenordnung angeben. So kann zum Beispiel die Schaffung neuer Arbeitsplätze (z.B. 20-30) der positive Effekt einer Anpassungsmaßnahme sein. Können Sie keine quantitative Angabe machen, greifen Sie bitte auf die nachstehend genannte qualitative Beurteilung zurück.

| +++ | ++ | + | 0 | - | -- | --- |
|---|---|---|---|---|---|---|
| sehr positiv | deutlich positiv | verhältnismäßig positiv | Neutral | etwas negativ | deutlich negativ | sehr negativ |

Im Hinblick auf die Investitionen und Wartungskosten ist es wichtig zu wissen, bei welchem Akteur diese Kosten entstehen. Versuchen Sie bitte bei einer Kostenteilung anzugeben, wie groß die Anteile jedes Beteiligten sind: zum Beispiel 1/3 eigenes Unternehmen, 2/3 Regierung.

**Auswirkungen von Anpassungsmaßnahmen**

| | | beste Maßnahme | zweitbeste Maßnahme | drittbeste Maßnahme |
|---|---|---|---|---|
| Einführungskosten | Investitionen | | | |
| | Wer investiert? | | | |
| | Wartung | | | |
| | Wer trägt Wartungskosten? | | | |
| Beschäftigung | Direkt (Zuwachs eigenes Unternehmen) | | | |
| | Indirekt (Zuwachs bei Lieferanten) | | | |
| Umwelt | Energieverbrauch (Reduzierung) | | | |
| | Luftqualität (Red. $SO_2$, PM10, $NO_x$) | | | |
| | Wasserverschmutzung (Reduzierung) | | | |
| | Lärm (Reduzierung) | | | |
| | Naturerhaltung | | | |
| | *Raumnutzung (Reduzierung m2)* | | | |
| | Transportsicherheit | | | |
| andere Effekte | öffentliche Akzeptanz | | | |
| | rechtliche Situation | | | |

Vielen Dank für Ihre Unterstützung.
Wenn Sie zusätzliche Anmerkungen haben, nennen Sie diese bitte.

Wir wären Ihnen sehr dankbar, wenn Sie uns den Fragebogen bis Freitag, den 16. September 2011 zurücksenden könnten. Das Porto übernehmen selbstverständlich wir für Sie."