Title: **Climate change and inland shipping**

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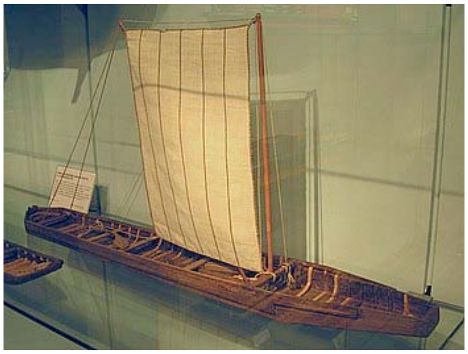


Fig.1: Old Roman Rhine vessel

Abstract:

Although much attention is given to the consequences of climate change with respect to melting icecaps, starving polar bears, sea level rise and inadequate storm defense systems, there may be severe consequences for inland shipping too.
Not only because of more frequent occurrence and longer durations of closed storm surge barriers, which may disconnect the free entrance for inland vessels to seaports, but also because the hinterland connections itself may change in the sense that so called melting rivers with a rather stable and predictable discharge over the year, may change in fast fluctuating and more unpredictable so called rain rivers. This may sometimes lead to higher water levels, which may give problems for the passage of bridges by (to) high inland (container) vessels, but what is more undesired are (long) periods of low discharge, which may allow only shipping with restricted shallow draught, which in turn may cause disruption of "lean and mean" logistic chains.

There are many different type of solutions to anticipate to this future threats, such as better river management (think about retention basins in times of high discharge or in times of low discharge think about inflow from reservoirs, flow reduction by weirs and adjustable groins, extra draught by dedicated dredging), other more shallow ship properties, extra and/or shifted fleet capacity, other transport modalities, more accurate, actual and long term predicted river depth information, logistic buffers, extra stock, etc.

An extra complication comes from the fact that some of these measures should be taken in the public domain by (inter)national government(s), local authorities, river managers, etc., while others are more or less the responsibility of private transport companies,

producers or even individual ship owners. And most of them are believers of the law of up scaling more than downsizing!

In this paper some results of the working group ‘Inland navigation’ from the project ‘Knowledge for Climate’ are presented and a few specific measures such as infrastructural adaptations are further investigated and scored against different criteria.

Keywords: Climate change, Inland shipping, River Rhine, Adaptive measures;

1. Introduction

Though we all know that change is the rule and a stand still is the exception, and though we did know from school already that climate has changed considerably in the past (think about ice ages) so there is a good reason to expect change in the future, we are suddenly waken up by Al Gore and his ‘inconvenient truth’ that this change is more near and severe than we ever thought.
In the 80^{th} we take into account a sea level rise of 0.2 meter per 100 years for the design of new sea defense structures in Holland, but nowadays the worst prediction of the new Delta Committee is about 1.30 meter for the next hundred years!

This implies a much more frequent closure of the main barriers and so the ‘free’ entrance of the hinterland connections to the sea ports. In this scenario for example the closing frequency of the Measlant barrier near Rotterdam should increase from 1 per 10 year to 30 times per year! So in the stormy season there is hardly any ‘free’ entrance left over, if not guaranteed by time consuming navigation locks.

At the same time climate change is expected to have influence on the river Rhine, which is the main hinterland connection from the Port of Rotterdam to industrial area’s in Germany and vice versa. Because it is expected that its character will change from a melting river with a more or less predictable high discharge in spring to a far more unpredictable rain river with high discharges, but what is more undesired with long periods of low discharges. This may result in periods with low water depth (if not regulated by groins and weirs), so in less capacity for individual inland vessels (if not specially equipped for that) and so perhaps in shortage of overall transport capacity for the main streams of dry and wet bulk or containers to the hinterland (which is in the order of 100 million tons per year).

Of course the climate change, as described in a few IPPC-scenario’s, is not the only change which may have an influence at the present hinterland connection.
There is the economic growth described in another few scenario’s by WTO, which has direct effect on the world wide trade, which may lead to shortage or opposite to overcapacity in the transport sector.
There is a long-term shift in transport modes from the environment unfriendly road transport to environment friendly and still reliable inland waterway transport.

There is a never ending growth in the scale of inland vessels, resulting in push boat configurations searching for the ultimate limits of the transport routes.
There is a long-term change in the bottom profile of the river Rhine, erosion caused by earlier shortening and narrowing of the bed profile or opposite sedimentation caused by widening of the riverbed (for instance the Dutch project Room-for-the river).

All though in reality all these changes work together, in the study undertaken under the auspician of Knowledge for climate the main focus of the working group for inland waterway transport was on the effect of climate change.

2. Description of the system and boundaries

To make clear what is inside and what is outside the scope of this paper based on the ongoing research project of Knowledge for Climate, first of all the boundaries of the system has to be defined.

The project focuses mainly on the transport of goods by inland navigation along the river Rhine from the Port of Rotterdam to the German hinterland till Koblenz and vise verca.

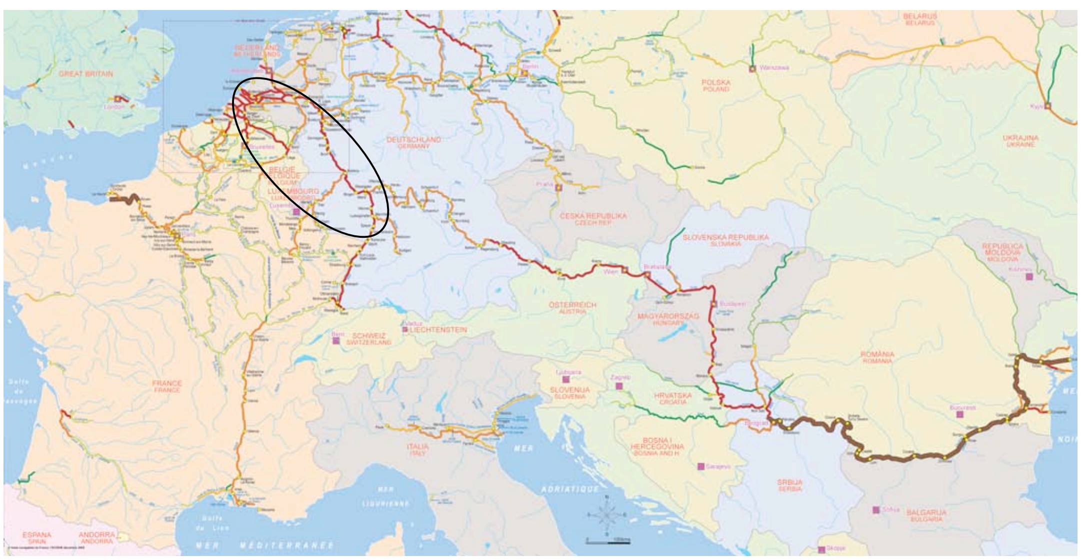


Fig. 2 System boundaries

Though from a logistic point of view other transport routes and/or transport modalities may play a role as well, here the primary scope is on the transport by inland navigation. But of course this boundaries are not taken so rigid that suboptimal solutions are described and the real optimal solution has been overlooked or even forbidden.

3. The problematic present and future situation

In the present time the discharge of the river Rhine already fluctuates in such a way that in so called ‘dry’ years, for instance the year 2003, there were periods of a few weeks that the water depths at certain critical parts were below the ‘guaranteed’ depth (OLR) of 2.50, 2.10 or 1.90 meters. So big inland container vessels and bulk barges with a draught from 1.50 up to 4.50 meter had hardly any transport capacity left over. At that time only very small inland vessels were able to carry goods to the hinterland, but their combined capacity was just enough to solve the most urgent problems.

So the expectation for the far future (e.g. the year 2050) will be that at that time the very ‘dry’ year of 2003 will then be a common year and together with the continuing up scaling of the fleet for inland navigation, there will be very few ‘shallow’ transport capacity left over, if no adequate measures were taken at that time.

But this rough expectation is not enough to prove that measures has to be taken and surely not enough to know which measure gives which effect and has to be taken at what time scale. So models are needed to predict the future situation without and later on with adaptive measures more accurate.

First a (hydraulic) model to describe the present situation and then the effect of climate change on the discharge and water depths of the river Rhine at known critical locations.

Second a (navigation) model to describe the present transport to the hinterland by inland navigation in normal years and then in ‘dry’ years, where certain trips with full loaded inland vessels are no longer possible.

Third a (logistic) model that can handle the present main streams and modal shift of containers and bulk goods to the hinterland, but also describes the effect of the reduced loading capacity of individual vessels on the main streams and resulting modal shift.

Fourth an (economic) model that describes the present costs of transport and the effect of reduced loading capacity and modal shift, which of course has influence on the short-term prices and reliability, but also on the long-term logistic choices.

It should be clear that integration of these (partly existing) models so that they can work with each other’s data and next calibration of the findings for a realistic but logistical complex present situation is far from easy, but should first be done to predict the far future with sufficient accuracy.

4. Desired future situations at different levels

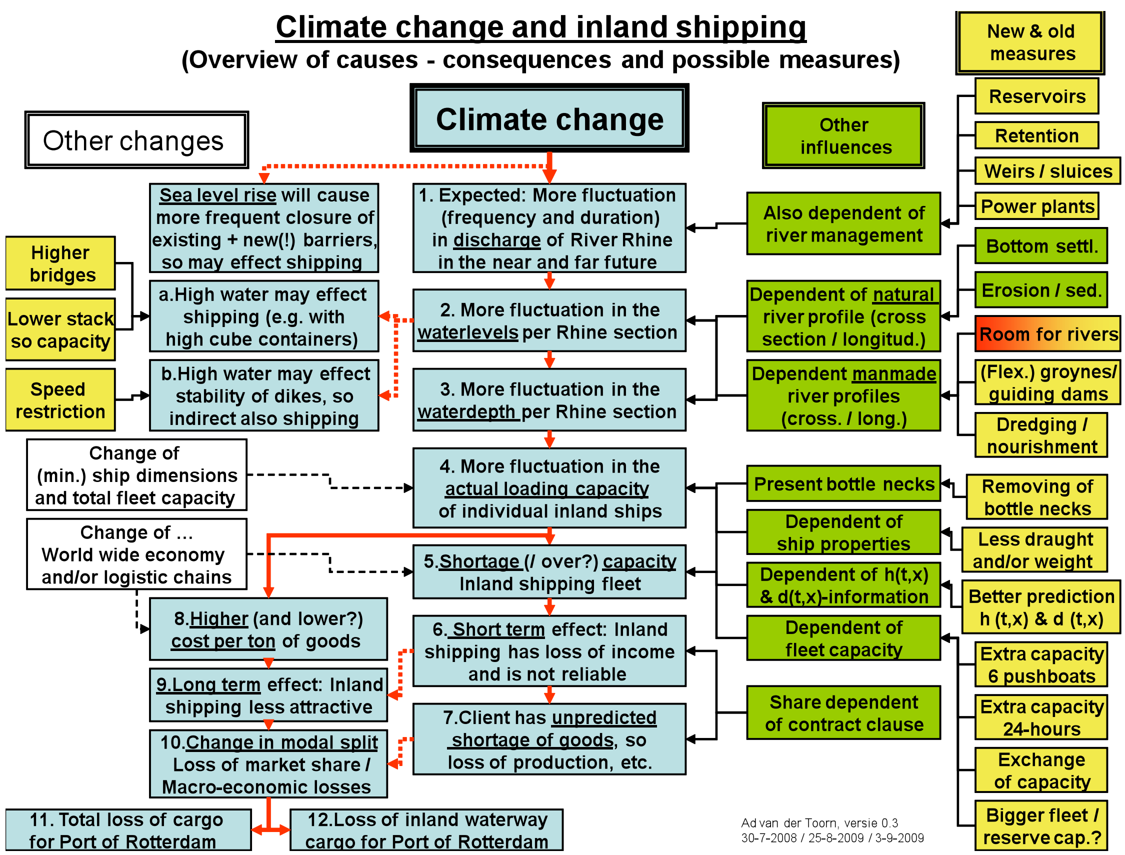
The desired situation at the horizon (e.g. the year 2050) should be such, that even in times of long lasting low discharges of the river Rhine (think about a month or so), it should be possible to mobilize enough transport capacity with respect to the inland navigation fleet, to guarantee the minimum requirements of the main streams of critical goods to or from production facilities, to consumers or opposite to the Port of Rotterdam.

A first remark has to be made to restriction that this minimum transport capacity should be mobilized by the fleet of inland navigation, which of course is attractive in normal times as a cheap and environment friendly way of transport, but from a logistic point of view this should not necessary be the case in times of urgency. Though it is not realistic to expect that the big stream of goods could simply be taken over by rail and/or by truck.

A second remark is about the minimum requirements of the main streams of goods which of course is directly dependent of the stock or storage capacity of the production facilities as such and the risk / consequences involved by their shortage or storage.

A third remark is about the criticality of the specific goods in the big streams that under normal condition goes up - or downstream the river Rhine. Just a percentage of these goods are really critical to the time of consuming or to production facilities.

So it must be clear that the definition of the desired situation from the scope of different stakeholders, may give an unneeded restriction to all the possible solutions!



5. Different type of solutions

Roughly speaking there are four main directions of possible solutions:

A. River management. Think about movable groins, weirs, reservoirs and retention basins, dredging, etc.
B. Fleet management. Think about inland navigation with vessels of smaller draught, so broader, longer, light weight materials, extra buoyancy, etc.
C. Information management. Think about up to date on line information about present and expected water depth, local water velocities, real-time draught and trim of the vessel, etc.
D. Logistic management. Think about other transport modalities, other routes, extra stock or storage capacity, extra handling facilities in harbors or at points of modal shifts, etc.

It should be clear that these four main type of solutions not only originates from different stakeholders, but also plays at different time scales and have different effects.

The improvement of the river discharge and so water depths by movable groins, weirs, reservoirs and retention basins will be realized by large scale infrastructural projects of billion euro's, financed by governments of different countries and may finally result in positive effects in the order of meters (see for instance the upper Rhine).

The improvement of the inland navigation fleet could not be realized by a single or a few players, not on a short term base and only if it will be profitable for the daily life as well as for the extreme conditions. While the final effect will be just a few decimeters.

The improvement of information management seems to be the picking of low hanging fruit, although the expected effect will be no more than in the order of a decimeter.

The improvement of the logistics may have a considerable effect with respect to extra stock or storage, but is in contradiction with the just-in-time philosophy, which strives for low stocks and it is questionable if the prediction of low water periods make extra stock possible. With respect to other routes and/or modalities it may be doubted if these big main streams in the order of hundred million tons per year could really be transported by other routes and/or modalities, even if they say that they are 'prepared' for it !?

6. Ranking solutions by effect, cost and time

A first ranking of the measure could be based on the effect that they will have on the (extra) water depth or what is directly related on the transport capacity of individual inland vessels and so on the **overall transport capacity**. Here river management is the most promising.

A second ranking of the measures could be based on the effect that they have on the reliability of the water depth, so on the **reliability of the overall transport capacity**.

A third ranking of the measures could be based on the effect that they have on the cost of individual trips, so on the **mean overall cost of the hinterland connection by inland shipping.**

A fourth ranking for different measures could be based on the **average trip duration** for different destinations. But because 'time is money', this could be combined with the third ranking.

7. Concluding remarks

Up till now the first runs with the integrated models give some insight in the change of transport capacity and modal shift for a 'dry' year, which is a normal year 2004, but dried up with the effect of climate change.
From these first results it can be seen that transport cost in the dry period may rise for some commodity groups like minerals and building materials with a factor up to 2. But over the year the cost effect will still be very small.
During dry periods there will be a certain modal shift, that depends on the commodity group, but there are still more questions than answers, because it is not clear if this modal shift is temporarily or permanent and has the other modality really enough capacity and reliability to take over these big streams of goods to and from the hinterland?
The first question to be answered is the **reliability of the models** in this extreme situation!