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CLIMATE RESILIENT INLAND WATERWAYS: A NOVEL SYSTEMIC APPROACH

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INTRODUCTION

In its AR6 report the IPCC (2021) projects *'with high confidence an increase in the variability of the water cycle in most regions of the world and under all emissions scenarios'.* She furthermore states that *'evidence of observed changes and attribution to human influence has strengthened … in particular for extreme precipitation, droughts, tropical cyclones and compound extremes (including fire weather)'.* Extreme precipitation and droughts cause discharge variations in river systems, which impact Inland Waterway Transport (IWT). Disrupted hinterland connections affect the performance of sea and inland ports, which, in turn, may disrupt (global) maritime supply chains with far reaching economic effects. The prolonged drought of 2018 in North-western Europe, for example, caused significant economic losses for Germany's industry. The reduced IWT capacity affected the production of energy, steel and chemical products.

Discharge extremes reduce the reliability of IWT. To prevent an undesired modal shift to road or rail, water transport networks need to become more climate resilient. We believe that to date IWT has received relatively (too) little attention in climate resilience studies, and measures have often been proposed from an oversimplified perspective. Furthermore, rivers and canals support multiple user functions, so IWT measures should be evaluated against other functions, and vice versa. This paper discusses a novel method to better account for IWT, using a systemic perspective and an integral approach.

METHODOLOGY

Our method consists of four consecutive steps:

1. In the first step we applied the Frame of Reference approach (Van Koningsveld and Mulder, 2004) to identify inland shipping objectives and decision protocols for both river managers and barge operators. We distinguished objectives for: capacity, safety, service levels, and sustainability. This allowed us to understand why actors behave the way they do .

2. In the second step we analyzed the IWT response to discharge extremes using river discharge and vessel loading data in the Netherlands. This allowed us to compare vessel behavior for various cargo types (containers, liquid bulk and dry bulk) during extreme low, normal and extreme high discharges (Vinke et al, 2023)

3. In the third step we developed a simulation approach to investigate to what extent objectives and decision protocols could be implemented to recreate observed behavior at systemic scale. This allowed us to uncover a number of key elements that need to be included in the simulation of the impact of discharge extremes on inland shipping, and to show that a systemic approach is needed to resolve important cascading effects (Vinke et al, 2022).

4. In the final step the outcomes of the first three steps were used to select adaptation measures which were evaluated quantitatively using a systemic approach.

All steps were applied on a waterborne transport case between Rotterdam and Duisburg via the Waal.

RESULTS

The research delivered the following outcomes:

- The Frame of Reference approach provides a clear and comprehensive overview of the objectives of two main stakeholders. We demonstrate that perspectives align during normal circumstances, but differences arise in case of discharge extremes.
- The data analysis showed that different cargo types respond different to the same discharge extreme. Dry bulk transport is quite redundant by sailing in smaller push-tow formations or with other type of vessels and the loss of capacity is compensated by a higher number of trips. In contrast, the fleet mix of tankers is small, so they have to adapt to the low conditions which results in a drop in performance. Container transport continues with the same number of deployments, but the average number of containers per vessel decreases (Vinke et al, 2023).
- Overall we saw that despite the higher deployment of vessels during prolonged droughts there is still a loss of transport capacity. The increased vessel deployment causes a higher berth occupancy which may affect operation of berth facilities (Vinke et al, 2022).
- Systemic behavior and cascading effects can be simulated by a novel simulation approach that connects predicted hydrodynamics with a Discrete Event and Agent Based logistics simulation package (Van Koningsveld, 2019).

CONCLUSION

The design of climate resilient inland waterways demands major investments by stakeholders in the waterborne transport sector. This paper provides a systemic and multi-sector approach to get a better understanding of systemic processes and cascading effects. This knowledge can be used in the decision-making about long term adaptation measures. The proposed research approach is demonstrated for waterborne transport via the most important corridor of the Dutch waterways, but is applicable to other rivers and inland waterways.

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