United Nations ECE/TRANS/WP.5/GE.3/2019/12

Economic and Social Council

Distr.: General
28 March 2019

Original: English

Economic Commission for Europe

Inland Transport Committee

Working Party on Transport Trends and Economics

Group of Experts on Climate Change Impacts and Adaptation for Transport Networks and Nodes

Eighteenth session
Geneva, 6 and 7 June 2019
Item 2 of the provisional agenda
Climate Change and Transport Networks and Nodes: Presentations of initiatives at national and international levels

Impact of climate change on the water management of the Kiel Canal*

Submitted by the Government of Germany

I. Introduction

1. This document provides a case study on impact of climate change on the water management of the Kiel Canal. The Group of Experts requested at the sixteenth session that this case study is tabled as on official document at future sessions.

2. The Kiel Canal ("Nord-Ostsee-Kanal" (NOK)) is the world´s busiest man-made-water-way navigable by seagoing ships. Annual roundabout 100 million tons of cargos were transported on the waterway. The canal provides a direct link for the North Sea ports to the Baltic Sea region. The NOK also serves as drainage of a catchments area of about 1,500 km² of Schleswig-Holstein. An important task within the Network of Experts of the Federal Ministry of Transport and Digital Infrastructure (BMVI) is the investigation of the dewatering of the Kiel Canal under climate change scenarios.

3. When balancing the interests of shipping, e.g. the requirements of the ferry crossings and hydrological and meteorological conditions, the drainage for the NOK must be controlled such that the water does not exceed or fall below its maximum and minimum levels respectively. A sea level rise (SLR) of around 20 cm in the past 100 years has already noticeably reduced the drainage times available. Looming climate change will result in a further rise in sea level, as well as in changes in the inland hydrology. Since it

* Nils H. Schade (Federal Maritime and Hydrographic Agency, Hamburg), A.D. Ebner von Eschenbach (German Federal Institute of Hydrology, Koblenz), A. Ganske (Federal Maritime and Hydrographic Agency, Hamburg), J. Möller (Federal Maritime and Hydrographic Agency, Hamburg), V. Neemann (Directorate General for Waterways and Shipping, Kiel)

GE.19-05104(E)
1905104

can be expected that the water levels in the tidal areas of the Elbe River and the Baltic Sea will continue to rise as well, the question arises whether the frequency of such tense dewatering situations will change in the future, and if so, how strongly the NOK and its catchments will be affected.

II. Methods

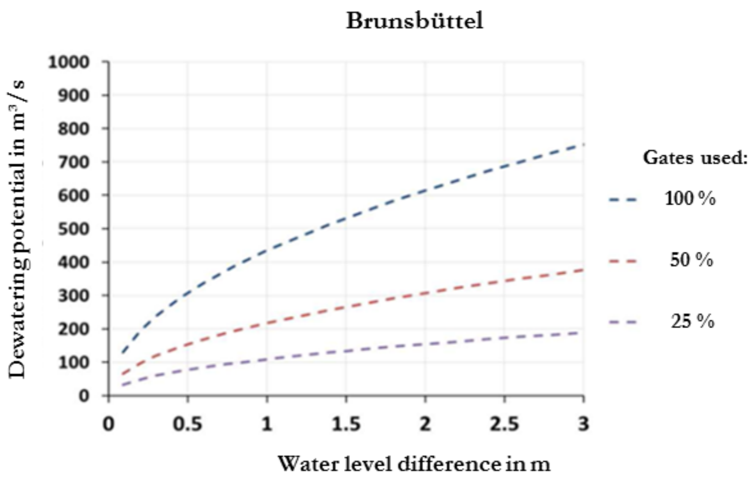
4. Two different approaches have been performed: On demand of the Federal Waterway and Shipping Agency (WSV), the Federal Institute of Hydrology (BfG) has developed a water balance model to simulate the runoff into the NOK from its catchment, as well as a canal balance model to simulate the NOKs water levels and drainage facilities.

5. In addition, the Federal Maritime and Hydrographic Agency (BSH) has investigated these serviceability limit states based solely on oceanographic and atmospheric parameters without running an extensive model setup. This way, both approaches, “model system” and “proxies/predictors”, can be compared. The “proxies/predictors” method has already been applied to the results of the climate model MPI-OM (Mathis et al., 2017) and possible future changes in long lasting precipitation and high outer water levels have been studied.

III. Results

6. The potential for drainage was calculated with the use of a correlation index from the water level difference between NOK and Elbe (see Fig. I). The NOK can only be drained into the Elbe during tidal low waters, when the water level of the Elbe is lower than the NOKs. The drainage of the NOKs catchment area is carried out to 90 per cent at the southwestern part (Brunsbüttel) in the Elbe. This is, because the water level difference between NOK and Elbe permits a more efficient dewatering as at the north-eastern part via Kiel-Holtenau into the non-tidal Baltic Sea. Therefore, only the drainage potential at Brunsbüttel is pictured here.

Figure I
Relation of water level difference (between Elbe and NOK) with dewatering potential at Brunsbüttel (Ebner von Eschenbach, 2017) for three possible usages of the sluice gates.

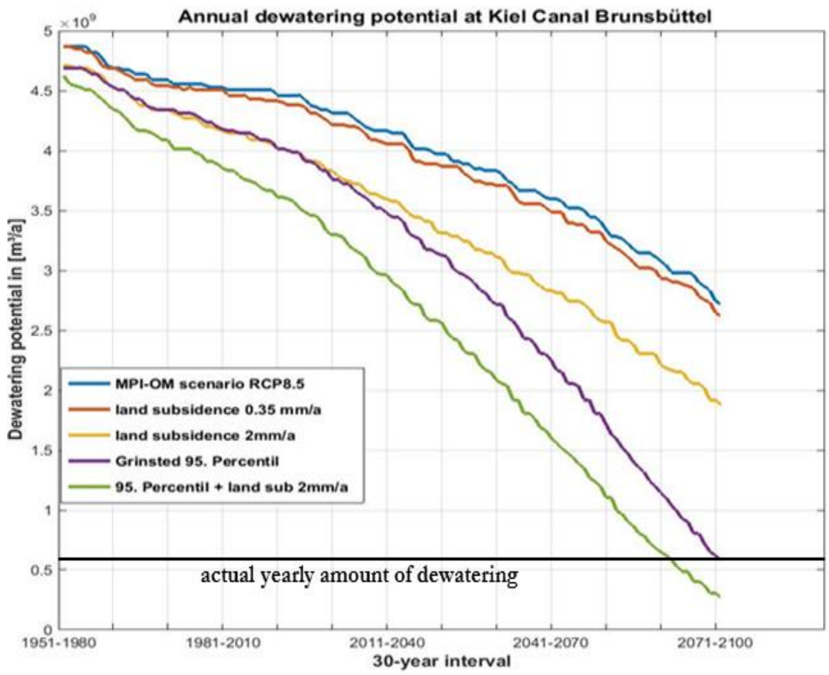


7. The climate model MPI-OM provides hourly water levels at the Elbe for the past (in the historical run) and for the future (here in the “business as usual”-scenario RCP8.5). The correlation of the hourly water level difference leads to an amount for the yearly drainage potential. The results are displayed in Fig. II. The impact of SLR on drainage potential is crucial; even an expected SLR of 55 cm would reduce the drainage potential of the NOK around about 40 per cent (see Fig. II, blue line represents a SLR of about 55 cm until 2100).

The future land subsidence in southwestern Schleswig-Holstein (yellow and orange lines) and more and heavier precipitation will reduce the drainage potential even further.

Figure II

Dewatering potential in climate change scenario RCP8.5 with/without effect of land subsidence and an estimation of additional polar ice melting. The black line indicates the actual yearly amount of dewatering needed (600 mill m³/year).



8. Extremely high tidal low waters reduce or even prevent the possibility of drainage. While it is not difficult to bridge a gap of one tide without dewatering, it is a major challenge in case there are two (or more) consecutive low waters higher than the water level in the NOK (at least 480 cm above gauge normal level). Table 1 displays the events of "no possibility to drainage" per 30-year period for different numbers (1 to 6) of consecutive low waters above the critical water level (480 cm): A rapid increase of consecutive high low waters in the future is apparent and statistically highly significant (at the 99 per cent level). While on average 10–12 events per year with low water levels higher than the respective water level in the NOK can be observed today, these events will occur much more frequently in the future due to the sea level rise.

Table 1

Number of events per 30-year period of low waters (LW) at Brunsbüttel higher than the design water level at Kiel-Canal, for one up to 6 consecutive low waters

LW Event	*1951–1980*	*1981–2010*	*2011–2040*	*2041–2070*	*2071–2100*
N=1	347	516	564	965	1 752
N=2	89	136	185	329	702
N=3	31	54	73	165	377
N=4	8	17	24	63	167
N=5	2	4	11	33	90
N=6	1	0	3	15	45

IV. Applications

9. With the help of the model system outlined above, serviceability limit states of the NOKs water management have been identified and possible changes in the occurrences

thereof have been derived. These analyses provide an important contribution to the Federal adaptation strategy on climate change. This task is characterized in the report “Adaptations to the global Climate Change” (“Fortschrittbericht Deutsche Anpassung an den Klimawandel, APA II, 2015”) of the German government with one focus on climate change and resilient traffic infrastructure for the NOK. The operating agency of the NOK, the WSV regards the model studies described above as an essential basis for decision-making to counteract the restriction for drainage of the NOK due to sea level rise and changing precipitation. Therefore, two options will be considered: A – an adapted water resources management and B – new construction of sluices.

10. Due to the results of the above described studies, the WSV investigates prospective approaches, for example long-term options for action, such as the creation of floodplains or the construction of a new „Kiel Canal pumping station”.

11. The substitution of sluices which ensure the undisturbed shipping traffic at the NOK will be planned with new findings about the accelerated sea level rise. The WSV will consider the prognosticated SLR of about 1.74 m (see Grinsted et al., 2015) instead the 0.50 m SLR formerly considered in the “General Plan on Coastal Protection” (“Generalplan Küstenschutz des Landes Schleswig Holstein - Fortschreibung 2012”). In this process, the sluice in Kiel-Holtenau will be planned in such a way that it will be possible to adapt the construction along with the actual SLR which in turn allows optimization of the consumption of resources in line with demands. The planned construction of the flood-gates for example was changed according to the optimization process.

V. Outlook

12. As a long term goal the combined occurrence of heavy and/or long lasting precipitation and high outer water levels will be investigated with an ensemble of climate models. Also, this method will be used to examine possible future changes in the dewatering of other river catchments in coastal areas, where no model setup exists.

VI. References

Bundesregierung, Fortschrittsbericht zur Deutschen Anpassungsstrategie an den Klimawandel, Stand: 16.11.2015. www.bmu.de/fileadmin/Daten_BMU/Download_PDF/ Klimaschutz/klimawandel_das_fortschrittsbericht_bf.pdf

Ebner von Eschenbach, A.-D. (2017): Simulation der Wasserbewirtschaftung des Nord-Ostsee-Kanals – Herausforderungen und Lösungsansätze. BfG-Veranstaltung. Kolloquiumsbeitrag "Modellierung aktueller Fragestellungen zur Wassermengenbewirtschaftung an Bundeswasserstraßen" am 13./14. September 2016 in Koblenz.

Grinsted, A., Jevrejeva, S., Riva, R.E.M., and D. Dahl-Jensen (2015): Sea level rise projections for northern Europe under RCP8.5, Climate Research, 64, 15–23. doi.org/10.3354/cr01309

Mathis, M., Elizalde, A., and U. Mikolajewicz (2018): Which complexity of regional climate system models is essential for downscaling anthropogenic climate change in the Northwest European Shelf?, Climate Dynamics, 50(7-8), 2637-2659. doi.org/10.1007/s00382-017-3761-3

Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein, Generalplan Küstenschutz des Landes Schleswig-Holstein - Fortschreibung 2012. www.schleswig-holstein.de/DE/Fachinhalte/K/kuestenschutz/ Downloads/Generalplan.html