CCNR
CENTRAL COMMISSION FOR THE NAVIGATION OF THE RHINE

Interim information from the Infrastructure and Environment Committee on the effects of climate change on the Rhine waterway
(June 2024)

0. Summary

Between 2008 and 2011, the CCNR published three reports on climate change and Rhine navigation based on the 4th IPCC report. In 2011, the CCNR instructed its then Permanent Technical Committee (TP) to continue to monitor the issue of climate change intensively and to submit a revised version of the submitted report by 2020 at the latest. The Infrastructure and Environment Committee (IEN), as the successor to the TP, last reviewed the conclusions based on the 5th IPCC report in 2019, with the result that they are still valid. New scientific findings on the hydrological regime of the Rhine are not expected to be available until after the publication and regionalization of the 6th IPCC report in 2024.

In 2023, the CCNR began preparations to update the assessment report on climate change and its impact on infrastructure. It became apparent that the regionalization of the results based on the 6th IPCC report will not be available in 2024, but in 2026 at the earliest. As initial results show that there are relevant differences between the regionalized results of the 5th and 6th IPCC reports, it makes sense to base the work on updating the IEN Committee's assessment report on these new results, even if this means postponing the work by a further two years.

The following work by other organizations is relevant for updating the Committee's assessment report:

In its report on "Climate change induced discharge scenarios for the Rhine basin" based on the 5th IPCC report, the ICPR expert group HCLIM came to the conclusion that the earlier statements on changes in Rhine runoff are basically confirmed, but with a wider range and that many projections show that existing management practices may reach their limits in the future. The ICPR expert group HCLIM therefore recommends a review of the ICPR climate change adaptation strategy.

The CHR is expected to publish its "RheinBlick2027" report with the results of the regionalization of the 6th IPCC report in 2027. Initial results could possibly be made available to the IEN Committee as early as 2026.

Initial preliminary projections by Deltares based on the Dutch KNMI'23 scenarios based on the 6th IPCC report show an increase in maximum annual runoff of 5 to 25 % by 2100 for all moderate and high emission scenarios at the gauge station of Kaub. The low flow over a period of seven days (NM7Q, an indicator of droughts) will be lower in all wet and dry scenarios. The decrease varies between 10 and 30 % for the year 2100.

Based on these considerations, the committee has therefore decided to postpone the update of the assessment report and publish interim information instead. The IEN Committee's assessment report is expected to be completed in 2027. Conclusions on the possible adaptation of the waterway infrastructure cannot be drawn from this yet. To this end, the further CHR studies as part of the "RheinBlick2027" project must first be completed.

1. Background

1.1. Activities of the IEN Committee

Between 2008 and 2011, the CCNR's Permanent Technical Committee (TP) drew up three reports on the effects of climate change on Rhine runoff and navigation:

i. The first report[1] from 2008 analyzes the effects of climate change on Rhine discharges and the impact on Rhine navigation and identifies measures to reduce the impact on inland navigation and the inland waterway infrastructure.

ii. The second report[2] , written in 2009, is an update of the first report and additionally summarizes complementary strategies, policies and activities of the Member States and the European Union as well as other international organizations such as the International Commission for the Protection of the Rhine (ICPR), the Commission for the Hydrology of the Rhine (CHR) and PIANC.

iii. The third report[3] , published in 2011, identifies possible activities to mitigate climate change by reducing emissions from inland navigation and adapting inland navigation and logistics to the negative effects of climate change.

In Resolution 2011-II-9[4] , the CCNR instructed its TP Committee to continue to closely monitor the issue of climate change and to submit a revised version of the submitted report by 2020 at the latest. The Infrastructure and Environment Committee (IEN), as the successor to TP, last reviewed the conclusions in 2019, with the result that they are still valid and that new scientific findings on the hydrological regime of the Rhine are not expected to be available until after the publication and regionalization of the sixth IPCC report in 2024.

In the meantime, the IEN Committee, in cooperation with the Economic Committee (ECO), has produced several editions of the reflection paper "Act Now!"[5] , which deals with low water and possible adaptation options. The Committee's assessment report on the effects of climate change on the Rhine waterway goes beyond low water and is also intended to identify changes in medium and high water discharge, analyze the effects and identify adaptation options.

At the meeting of the IEN/G working group on 21 February 2024, the CHR and the ICPR reported on the timetable for updating their reports that the regionalized discharge data based on the sixth report of the Intergovernmental Panel on Climate Change will not be available until 2026 at the earliest. The completion of the assessment report must therefore be postponed accordingly. In the meantime, the Committee is publishing this interim information on the CCNR's current work on climate change.

1 https://www.ccr-zkr.org/files/infovoiedeau/Resolution2008-I-12_de.pdf
2 https://www.ccr-zkr.org/files/infovoiedeau/Resolution2009-I-5_de.pdf
3 https://www.ccr-zkr.org/files/infovoiedeau/Resolution2011-II-9_de.pdf
4 https://www.ccr-zkr.org/files/documents/resolutions/ccr2011_IId.pdf
5 https://www.ccr-zkr.org/13020156-en.html

1.2. Activities of other international organizations

Intergovernmental Panel on Climate Change (IPCC)

The following reports of the working groups on the 6th report of the Intergovernmental Panel on Climate Change (AR6) have been published so far:

- Report of Working Group 1 "The Physical Science Basis" on August 9, 2021[6]
- Report of Working Group 2 "Impacts, Adaptation and Vulnerability" on February 28, 2022[7]
- Report of Working Group 3 "Mitigation of Climate Change" on April 2, 2022[8]

The **synthesis report**[9] was published on March 20, 2023 to provide information for the 2023 global stocktake under the United Nations Framework Convention on Climate Change.

The reports of the Intergovernmental Panel on Climate Change contain the basic statements on climate change worldwide and for Europe. Regional statements on temperature and precipitation changes require a regionalization of the models of the Intergovernmental Panel on Climate Change. This regionalization is carried out for the Rhine region by CHR.

European Commission

On February 24, 2021, the European Commission adopted its new EU Strategy on Adaptation to Climate Change[10]. The strategy is a central component of the European Green Deal. It aims to strengthen and accelerate the EU's efforts to protect nature, people and livelihoods from the unavoidable impacts of climate change. The strategy has four main objectives: smarter, faster and more systematic adaptation and stepping up international action on climate change adaptation.

In its NAIADES III Communication "Boosting future-proof European inland waterway transport"[11], the European Commission publishes its action plan for the fundamental transformation of transport systems towards zero-emission mobility by 2030. This requires an integrated multimodal approach that explicitly aims to promote the use of more sustainable and less congested modes of transport.

The implementation of NAIADES is supported by the PLATINA projects funded by the EU. The PLATINA3 project provides for targeted coordination and support measures to promote inland navigation in Europe. The project began in January 2021 and ran for 30 months. As part of this project, a report on adaptation strategies for inland navigation infrastructure to climate change[12] was also published.

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6 https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/
7 https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/
8 https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/
9 https://www.ipcc.ch/assessment-report/ar6/
10 https://ec.europa.eu/clima/eu-action/adaptation-climate-change/eu-adaptation-strategy_en
11 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0324
12 https://platina3.eu/climate-change-adaptation-strategies/

[13]The Joint Research Center (JRC) of the European Commission is currently working on the 4th part of the PESETA study "Projection of Economic impacts of climate change in Sectors of the European Union based on bottom-up Analysis" on projections of the economic impacts of climate change in the sectors of the European Union based on a bottom-up analysis as well as on the "European Drought Risk Observatory (EDO)"[14] , an activity on the consequences of droughts on Europe in the framework of the Copernicus program.

The PESETA IV study[15] aims to better understand the impacts of climate change on Europe for a number of sectors affected by climate change and how these impacts could be avoided through mitigation and adaptation measures. The PESETA IV study "Global warming and drought impacts in the EU"[16][17] also looks at the consequences of low water for inland navigation vessels and proposes measures such as lighter inland vessels.

EDO[18] , the European Drought Observatory, is part of the Copernicus emergency management service and provides drought-related information and early warnings for Europe. EDO also produced the "European Drought Risk Atlas" report[19] , which also contains information for inland navigation.

United Nations Economic Commission for Europe (UNECE)

Through standards, conventions and policy support, the UNECE provides practical tools to support countries in their efforts in the four action areas of climate change mitigation, adaptation to climate change, mobilizing finance and strengthening cooperation. The UNECE provides a harmonized legal and regulatory framework for the decarbonization of mobility and transport[20], supported by a strategy of the Inland Transport Committee (ITC)[21] to reduce greenhouse gas emissions.

Inland waterways and ports are critical transportation resources and are under unprecedented threat from an already changing climate. By 2100, over 60% of the EU's seaports could be at high risk of flooding. The UNECE is analyzing the main risks and hazards in order to strengthen the resilience of transport infrastructure by identifying appropriate and most cost-effective adaptation measures.[22]

Commission for the Hydrology of the Rhine (CHR)

The CHR study "Impact of climate change on the rain, snow and glacier melt components of streamflow of the river Rhine and its tributaries"[23] on climate change and low water in the Rhine catchment was published in 2022.
The CHR report "Impact of regional climate change on discharge in the Rhine River basin (formerly "RheinBlick2050")"[24] is being updated.

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13 https://www.copernicus.eu/en (Copernicus is an EU program for the development of European information services based on satellite-based earth observation and in-situ data).
14 https://drought.emergency.copernicus.eu/
15 https://joint-research-centre.ec.europa.eu/peseta-projects_en
16 https://joint-research-centre.ec.europa.eu/system/files/2020-05/pesetaiv_summary_final_report.pdf
17 https://joint-research-centre.ec.europa.eu/system/files/2020-05/pesetaiv_task_7_drought_final_report.pdf
18 https://drought.emergency.copernicus.eu/tumbo/edo/map/
19 https://publications.jrc.ec.europa.eu/repository/handle/JRC135215
20 https://unece.org/transport
21 https://unece.org/transport/publications/itc-strategy-until-2030
22 https://unece.org/transport/press/unece-study-maps-transport-infrastructure-high-risk-due-climate-change-pan-european
23 https://www.chr-khr.org/en/news/when-melt-water-missing-more-often-low-water-expected-rhine-future
24 https://www.chr-khr.org/en/project/impact-regional-climate-change-discharge-rhine-river-basin-rheinblick2050-2007-2011

The CHR report on socio-economic scenarios (SES)[25] is being updated. Changes in socio-economic activities can lead to changes in water use and water consumption, and also influence the discharge of the Rhine.

The discharge forecasts for the Rhine required for updating the IEN Committee's assessment report on adapting the waterway and Rhine navigation to the effects of climate change also form the basis for updating the CHR report "Rheinblick 2050". The CHR estimates that the regionalization required for this will take around 2 years and could be available in 2026 and that the "RheinBlick2027" report[26] is expected to be published in 2027. (See also the minutes of the 92nd meeting of the CHR, item 3.01[27]). The study on the effects of melting snow and glaciers already shows that the absence of these runoff components in summer will exacerbate possible periods of low water.

International Commission for the Protection of the Rhine (ICPR)

The ICPR climate change adaptation strategy[28] 2015 already included shipping and its possible restrictions due to high and low water. According to the strategy, low water could lead to lesser loads and greater restrictions on shipping. Ship sizes would therefore have to be adjusted and shipping channels deepened in order to ensure navigation even at low tide.

In February 2020, the responsible ministers and their representatives adopted the "Rhine 2040" program. It aims to create a sustainably managed Rhine catchment area with valuable lifelines for people and nature that is resilient to the effects of climate change. Various global environmental problems - above all biodiversity loss, environmental pollution and climate change - have an impact on the water cycle. The ICPR will continue to update its climate change adaptation strategy until 2025.[29]

In 2024, the ICPR published a report by the HCLIM expert group on "Climate change induced discharge scenarios for the Rhine basin". The report is an update of the ICPR runoff scenario study based on the 5th IPCC report. The HCLIM expert group comes to the conclusion that

- previous statements on change are basically confirmed, but the range is widening,
- a change towards more rain-fed runoff regimes to the detriment of snow- or glacier-fed runoff regimes is to be expected in the Rhine catchment, and
- As a result, the discharge decreases in summer and increases in winter, whereby the average annual discharge hardly changes.

These conclusions are also used by the CHR for its work on the regionalization of the 6th IPCC report. The ICPR also requires the results of this regionalization for the update of the climate change adaptation strategy, which are expected to be published by the CHR with the RheinBlick2027 report in 2027.

25 https://www.chr-khr.org/de/projekt/sozio-oekonomische-szenarien-ses-2018-2021
26 2027 refers to the year of the planned publication.
27 https://www.chr-khr.org/sites/default/files/chrpublications/CHR_92_public.pdf
28 https://www.iksr.org/fileadmin/user_upload/DKDM/Dokumente/Fachberichte/DE/rp_De_0219.pdf
29 https://www.iksr.org/de/themen/klimaaenderung

World Association for Waterborne Transport Infrastructure (PIANC)

Following the publication of the report in 2008 of Task Group 3 "Climate Change and Navigation - Waterborne Transport, Ports and Waterways: A Review of Climate Change Drivers, Impacts, Responses and Mitigation", PIANC concluded that continuous action is needed to monitor and respond to the evolving challenges of climate change. A cross-commission Permanent Task Group on Climate Change (PTGCC) was therefore established. [30]

The following working groups and reports are relevant:

- TG3: The report of Task Group 3 on Climate Change and Shipping[31] was updated and published in 2023 as "Waterborne Transport, Ports and Waterways: A 2023 Update of Climate Change Drivers and Impacts".
- TG193: The report of Task Group 193 on "Resilience of the Maritime and Inland Waterborne Transport System"[32] was published in 2020.
- WG178: The report on "Climate Change Adaptation Planning for Ports and Inland Waterways"[33] was published in 2020.
- WG188: The report on "Carbon Management for Port and Navigation Infrastructure"[34] was published in 2019.
- WG249: The working group on "Adaptation of inland waterways infrastructure for climate change impacts" began its work in 2024.

2. Effects of climate change on the Rhine discharge

2.1. Conclusions from the fourth IPCC report

In 2011, the CCNR concluded on the basis of the scientific findings presented by the ICPR and the CHR that there will be no clear changes in the hydrological regime by 2050 compared to today. From 2050 onwards, the effects of climate change on the functioning of infrastructure structures cannot be ruled out. Therefore, no immediate infrastructure measures are urgently required. All three CCNR reports on climate change (see also Chapter 1.1) and the scientific input of the CHR and ICPR were based on the fourth IPCC report, the results of which were published in 2007.

2.2. Conclusions from the fifth IPCC report

Investigations by the member states, the ICPR and the CHR from 2019 show that there has been no significant change in the hydrological regime of the Rhine catchment between the regionalized results of the 4th and 5th IPCC reports. The IEN Committee therefore came to the conclusion in 2019 that the results from 2011 are still valid. However, on the basis of further developed hydrological models, the climatic effects on temperature and precipitation predicted by the climate models could be modeled more meaningfully. This resulted in more reliable statements on the effects of climate change on the Rhine discharge.

30 https://www.pianc.org/permanent-task-group-on-climate-change
31 https://www.pianc.org/publication/waterborne-transport-ports-and-waterways-a-2023-update-of-climate-change-drivers-and-impacts/
32 https://www.pianc.org/publications/envicom/tg193
33 https://www.pianc.org/shop/download/12611
34 https://www.pianc.org/publications/envicom/wg188

No significant effects of climate change on Rhine shipping are expected until 2050. Moderate increases in precipitation are predicted for winter. Increased winter precipitation, which also increasingly falls as rain instead of snow due to the higher temperatures, may lead to a moderate increase in medium and low water discharges as well as flood discharges downstream of Kaub. The results of the forecasts for the summer show no clear trend for precipitation. Discharge will remain more or less unchanged in summer compared to the current situation.

The following changes in the water balance and runoff regime are expected from 2050 onwards:

In the hydrological winter half-year: (November to April)
- Increase in precipitation
- Increase in outflows
- Early melting of snow/ice/permafrost, shift in the snow line

In the hydrological summer half-year: (May to October)
- Decrease in precipitation
- Decrease in outflows
- Increase in low water periods

2.3. Initial findings from the sixth IPCC report

The sixth IPCC report (synthesis report) was published in 2023. The report presents the latest forecasts for global climate change. The projections are based on the latest scientific findings and the latest climate models. Important key messages are that:
- the global surface temperature in the period 2011-2020 is 1.1°C above the value of 1850-1900,
- global greenhouse gas emissions have continued to increase,
- far-reaching and rapid changes have occurred in the atmosphere, the oceans, the cryosphere and the biosphere,
- climate change is already having an impact on many weather and climate extremes in all regions of the world, and
- for any given future level of warming, many climate-related risks are rated higher than in the AR5,

The global effects on temperature and precipitation are shown in the following graphic from the 6th IPCC report.

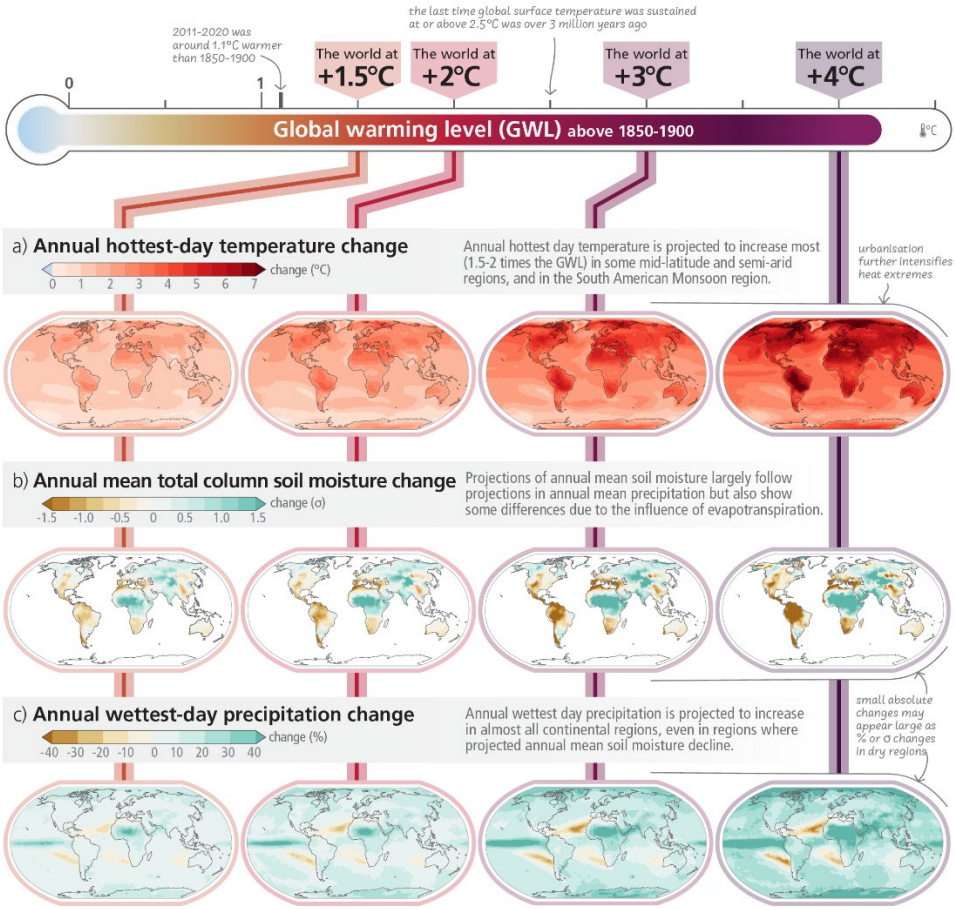

Figure 1: Global warming and impact on precipitation (Source: IPCC, 6th Synthesis Report)

The first regionalized data for the Rhine is expected to be available from 2026.

So far, only the Dutch Meteorological Institute (KNMI) has presented a set of climate projections, KNMI'23, which are in line with the latest scenarios from the sixth report (and are an update of the KNMI'14 scenarios based on the fifth IPCC report).

Based on the KNMI'23 scenarios, Deltares analyzed the effects on the discharge regime of the Rhine[35] . The results are preliminary and can only be used if the assumptions made are taken into account. Further work for the entire Rhine catchment area by the CHR is required. Nevertheless, the preliminary results show initial trends.

Climate change will lead to a further rise in temperatures in the catchment area. In the high emission scenarios, the temperature of the Rhine catchment area could rise by an average of six degrees by 2150. The rise in temperature will lead to an increase in water losses through evaporation. In addition, the climate scenarios also predict changes in precipitation. These changes vary depending on the season and sub-catchment area.

35 "The implications of the KNMI'23 scenarios for the Rhine and Meuse rivers", Deltares, 2024

Initial preliminary results for the Rhine discharge show that the change in the mean annual discharge as an indicator is uncertain. The risks of climate change can be positive (2 out of 6 scenarios) or negative (4 out of 6). However, if the summer and winter periods are considered, the annual winter discharges are higher in all scenarios and the annual summer discharges are significantly lower in all scenarios. The annual low water discharges also indicate that the discharges will be lower in all scenarios. It is therefore to be expected that the climate risks for Rhine shipping will increase.

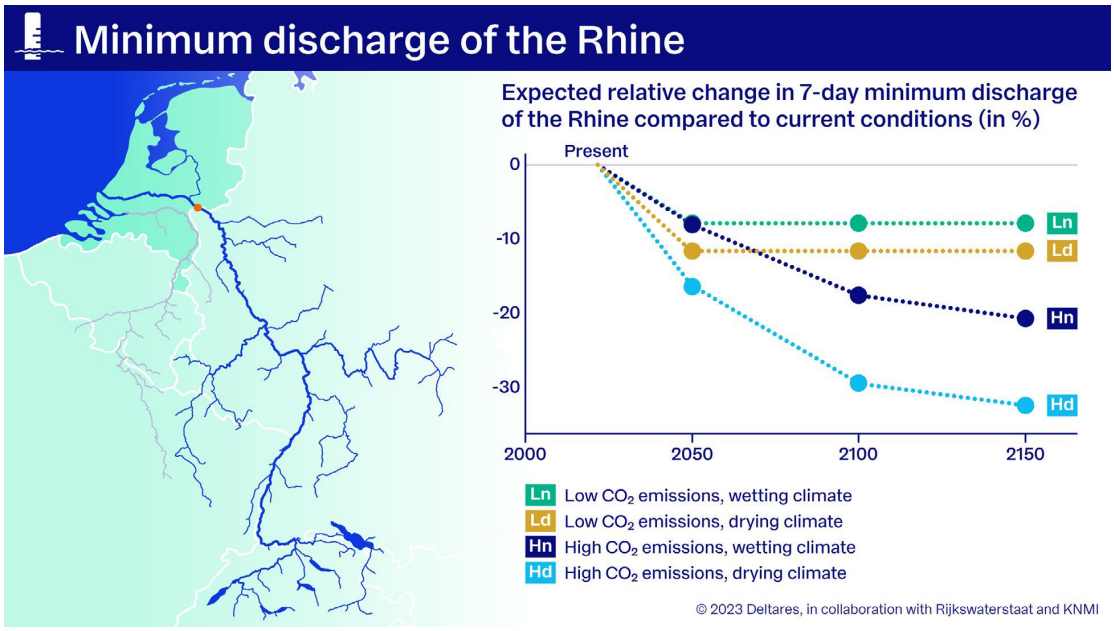

Figure 2: Change in mean annual low flow (NM7Q) at Lobith (Source: Deltares)

The preliminary projections for all moderate and high emission scenarios show an increase in maximum annual runoff of 5 to 25 % by 2100. The low flow over a period of seven days (NM7Q, an indicator of droughts) will be lower in all wet and dry scenarios. The decrease varies between 10 and 30 % for the year 2100.

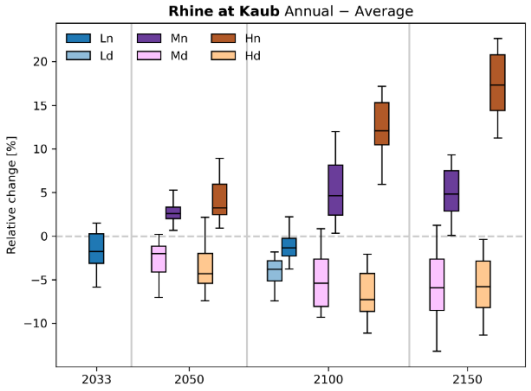

Figure 3: Change in mean annual runoff at Kaub (source: Deltares)

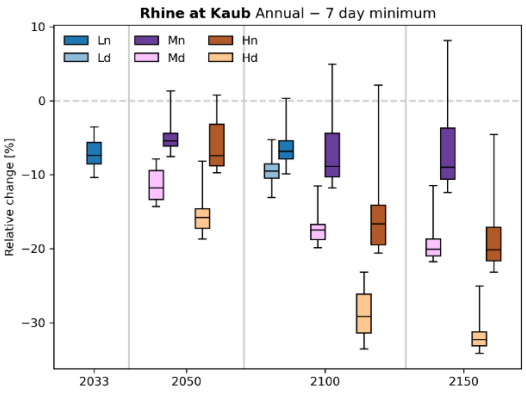

Figure 4: Change in mean annual low flow Water discharge (NM/Q) at Kaub (source: Deltares)

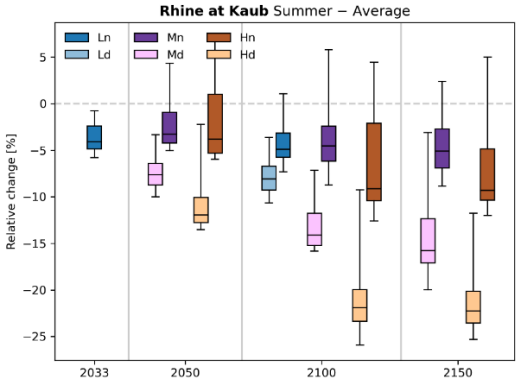

Figure 5: Change in mean discharge in the Summer half-year at Kaub (Source: Deltares)

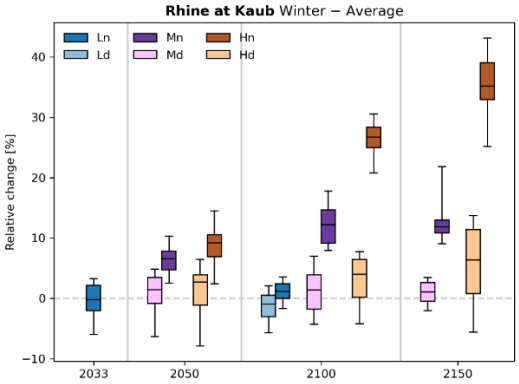

Figure 6: Change in mean discharge in the Winter half-year near Kaub (Source: Deltares)

3. Conclusions on the adaptation of waterway infrastructure to climate change

To date, the IEN Committee has taken the view that there will be no clear changes to the hydrological regime by 2050 compared to today. From 2050 onwards, the effects of climate change on the functioning of infrastructure structures cannot be ruled out. These conclusions were based on the regionalized results of the fourth and fifth IPCC reports.

In its report on "Climate change induced discharge scenarios for the Rhine basin" based on the 5th IPCC report, the ICPR expert group HCLIM came to the conclusion that the previous statements on changes in Rhine runoff are basically confirmed, but with a greater range and that existing management practices may reach their limits in the future.
The sixth IPCC report concludes that far-reaching and rapid changes have occurred, that climate change is already having an impact on many weather and climate extremes and that many climate-related risks must be rated higher than in the fifth IPCC report.

Nevertheless, it is not yet possible to decide on this basis which specific measures should be taken and when. This is shown in particular by the ICPR's conclusions for the Rhine with reference to the wide ranges of the model results. Therefore, the regionalized results from the CHR's RheinBlick2027 study must first be awaited.

Irrespective of the results of the RheinBlick2027 study, so-called "no-regret measures" can already be implemented today, for example to improve navigation conditions at low water in conjunction with supporting the achievement of the objectives of the Water Framework Directive (WFD), whereby the objectives of the Regulation on Union guidelines for the development of a trans-European transport network (TEN-T) could also be taken into account.

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