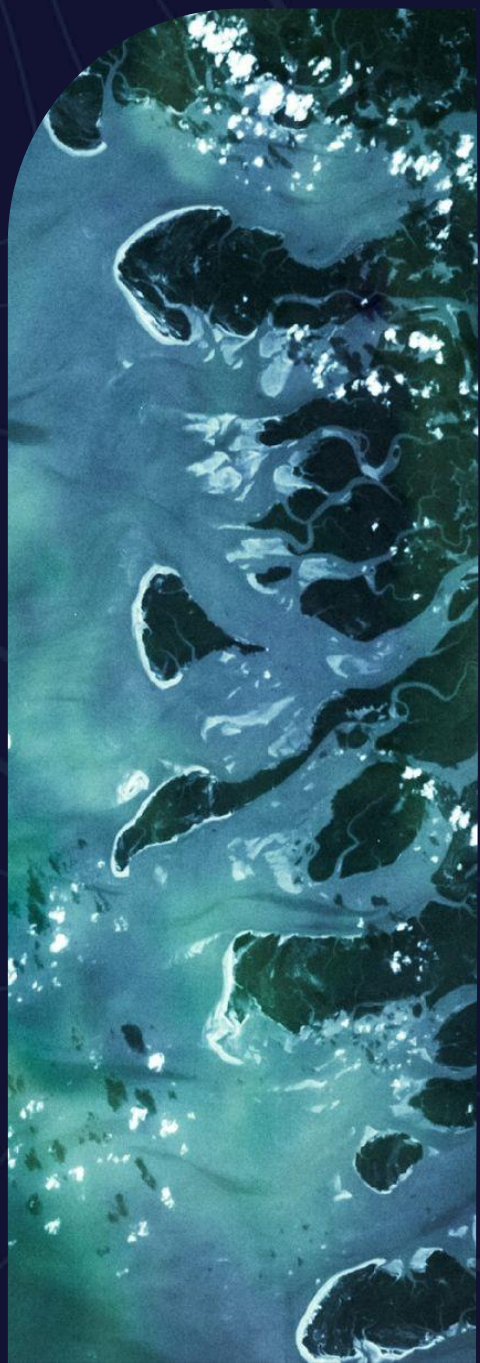
JCAR ATRACE

Knowledge Agenda

JCAR ATRACE, 30 June 2024



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Summary

The mission of the JCAR ATRACE programme is to improve transboundary cooperation in flood and drought management and research. This knowledge agenda describes *which* topics JCAR intends to research for that purpose and *how* JCAR will organize this. This report also shows that the knowledge agenda will be kept up to date and relevant for stakeholders through constant interactions with the JCAR community during the execution of the programme. The agenda forms one of the foundations on which JCAR will develop and foster long-term research partnerships.

JCAR aims to support flood and drought risk management in transboundary regional river basins in the Benelux and neighbouring countries to strengthen adaptation measures and policy. However, rather than developing yet more alternative instruments and measures, JCAR ATRACE will instead test, improve, extend, and integrate existing frameworks, concepts, models, and datasets with a view on tailoring the current available knowledge into policy and adaptation action.

The knowledge development in JCAR ATRACE is built upon the IPCC Framework on Risk and connecting five themes: extreme hazards, exposure, vulnerability, compound risk and adaptation measures. We add to that a supporting theme on Technology development.

The development of knowledge in this programme is organised according to defined roles, responsibilities and a clearly defined planning process of research activities. The JCAR knowledge programme is flexible, and new research questions can be addressed for each of the five themes in co-creation with stakeholders.

Contents

1 Introduction

1.1 The position of the knowledge agenda in JCAR ATRACE

The mission of the JCAR ATRACE programme is to improve transboundary cooperation in flood and drought management and research. This knowledge agenda describes *which* topics JCAR intends to research for that purpose and *how* JCAR will organize this. This report also shows that the knowledge agenda will be kept up to date and relevant for stakeholders through constant interactions with the JCAR community during the execution of the programme. The agenda forms one of the foundations on which JCAR will develop and foster long-term research partnerships. As such the knowledge agenda is one of the three major outputs from pillar 1 of the JCAR ATRACE programme as visualized in Figure 1. It will also scope the research activities for pillar II.

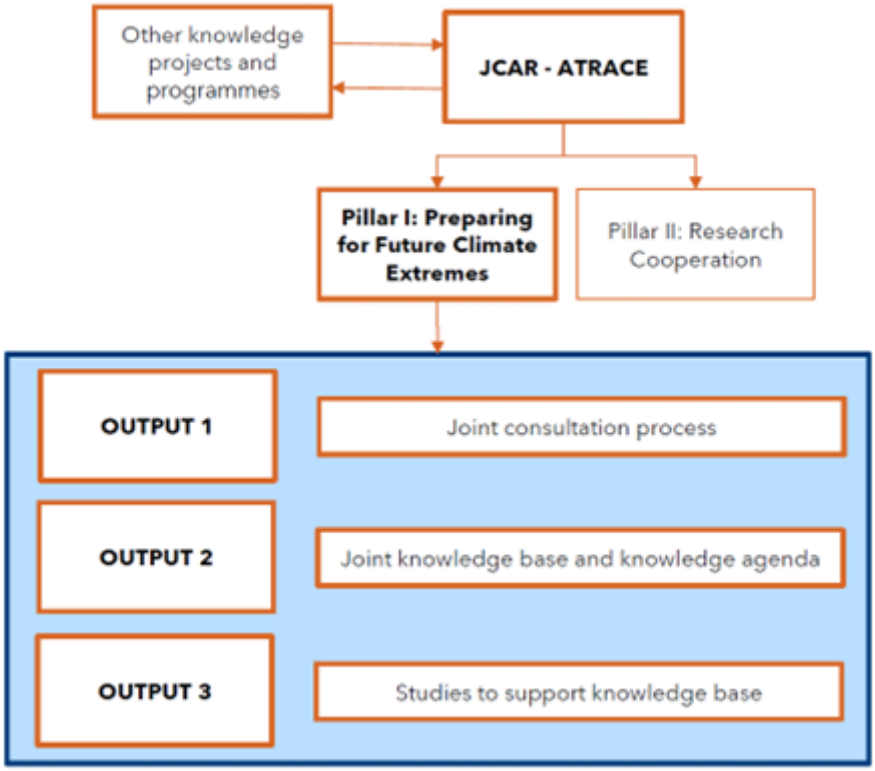

Figure 1: Schematic representation of pillar I outputs (JCAR ATRACE Programme Plan, 2023)

Through the knowledge agenda the JCAR ATRACE partners align on common research goals they aspire to achieve in the programme. The research questions aim to be policy-relevant and connected to the needs of the JCAR knowledge clients. The outcomes of the research scoped within the

knowledge agenda will enhance the knowledge base and facilitate regional governments to reduce transboundary flood and drought risks.

The knowledge agenda serves as a guiding document throughout the duration of the JCAR programme. It can be seen as a structured inventory of policy-relevant knowledge agenda topics fed by the input from several different channels. As such it is a 'living' document that will evolve with time. The knowledge agenda will be updated annually as part of the annual plan.

Knowledge agenda as a central element and its connections

Other **related** strategic programme (plan) documents in JCAR ATRACE - as a specification of the original programme plan - are:

- **capacity building and knowledge sharing plan** to elaborate on research and educational activities to enhance scientific knowledge sharing between JCAR ATRACE institutes and the building of a knowledge community network with experts and stakeholders;
- **research programme and implementation plan** to identify the joint long-term PhD-research topics and core values and conditions of he JCAR ATRACE PhD-community; and
- **the programme communication (and dissemination) strategy**, outlining the overarching goals and objectives the programme aims to achieve through its communication efforts by defining target audiences, key messages and overall approach to convey information to meet the programme's objectives.

The JCAR ATRACE annual plan(s) will refer to these plans and program the identified in an appropriate manner.

1.2 Glossary: terminology used in the JCAR ATRACE knowledge agenda

The JCAR ATRACE knowledge agenda is build upon terminology further defined below and inspired by IPCC 2022 AR6.

Hazard: Refers specifically to physical manifestations of climatic variability or change, such as droughts, floods, episodes of heavy rainfall, long-term changes in the mean values of climatic variables, potential future shifts in climatic regimes and so on. Hazards as described in this document are purely physically defined.

Exposure: Defined as the presence of people; livelihoods; species or ecosystems; environmental functions, services and resources; infrastructure; or economic, social or cultural assets in places and settings that could be adversely affected by extreme hydro-climatic events.

Vulnerability: Vulnerability is the least well-defined term in risk assessments and a wide range of descriptions of *vulnerability* can be found in the literature. In this JCAR knowledge agenda we use the term being the degree to which human and natural systems are susceptible to, or unable to cope with, extreme hydro-climate events, trends or disturbances, such that essential functions, identity and structure as well as biodiversity cannot be maintained. JCAR considers vulnerability across people; livelihoods; species or ecosystems; environmental functions, services and resources; infrastructure; or economic, social or cultural assets. To that end it may address a range of factors: technology, social acceptance, multistakeholder engagement, reduction of inequality, policy, governance, financing and capacity building.

Risk: Is a function of exposure, hazard and vulnerability. It is the potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems. In the context of extreme events, risks can arise from potential impacts of these events as well as human responses to the events. Relevant adverse consequences include those on lives, livelihoods, health and well-being, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species[3].

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be

distinguished to reduce risk, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Adaptive capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences[5].

JCAR will discuss these topics at the local to regional scales.

Local scale: Cities, municipalities, NUTS-3 regions, typically 10-100 km^2.

Regional scale: NUTS-2, up to river basins, 100-10 000 km^2.

Local development: A process of transformation of the local economy and society, oriented to surpass the difficulties and existent challenges related to socio-economic, demographic and climate change.

1.3 Objectives of the knowledge agenda

The main objectives of this knowledge agenda are to define:

- The themes and main topics JCAR ATRACE is going to address;
- How JCAR ATRACE will organize this research; and
- How JCAR ATRACE will keep the agenda relevant during the program.

To do this, this document elaborates on:

- The framework we adopt and themes we identified to organize the research topics, including a preliminary list of research ideas;
- How JCAR will include the wishes about the research directions of the competent authorities;
- How JCAR will support capacity building and incorporated into the education activities of the research partners;
- How JCAR will balance the prioritization of topics between the desires of the authorities and those of the scientific community.

2 Scope of research

Weather extremes seem to change faster than most had anticipated. Yet, in spite of the availability of copious amounts of information on climate change and its impacts from a range of sources, adaptation to ongoing and unavoidable future climate change is proceeding much more slowly than many had hoped. JCAR aims to support flood and drought risk management in transboundary regional river basins in the Benelux and neighbouring countries to strengthen adaptation measures and policy. However, rather than developing yet more alternative instruments and measures, JCAR ATRACE will instead test, improve, extend, and integrate existing frameworks, concepts, models, and datasets with a view on tailoring the current available knowledge into policy and adaptation action.

The JCAR ATRACE knowledge agenda outlines the knowledge development required to develop a portfolio of strategies, including nature-based approaches, to mitigate the consequences of (climate-change) induced weather extremes in transboundary small and medium sized river basins. It is built on our most recent up-to-date knowledge on the different strategies for resilient adaptation to these extreme events.

Where the JCAR ATRACE research addresses (nature-based) solutions to mitigate or avoid the most adverse consequences of the hazards, we acknowledge that implementing such measures is not justified by mitigation of extreme events only; Extreme events are rarely the sole or even primary reason for many risk (nature-based) mitigation-related actions. Where JCAR ATRACE will address implementation of solutions we will therefore evaluate this implementation in the context of local development plans, plans to improve environmental conditions for increasing biodiversity and/or mitigate greenhouse gas emissions. We build the knowledge agenda upon the IPCC framework (see figure 2) using the themes:

1. Extreme Hazards
2. Exposure
3. Vulnerability
4. Compound Risk and adaptation measures

And add one supporting theme on ‘Technology development’ to support assessments in the other themes.

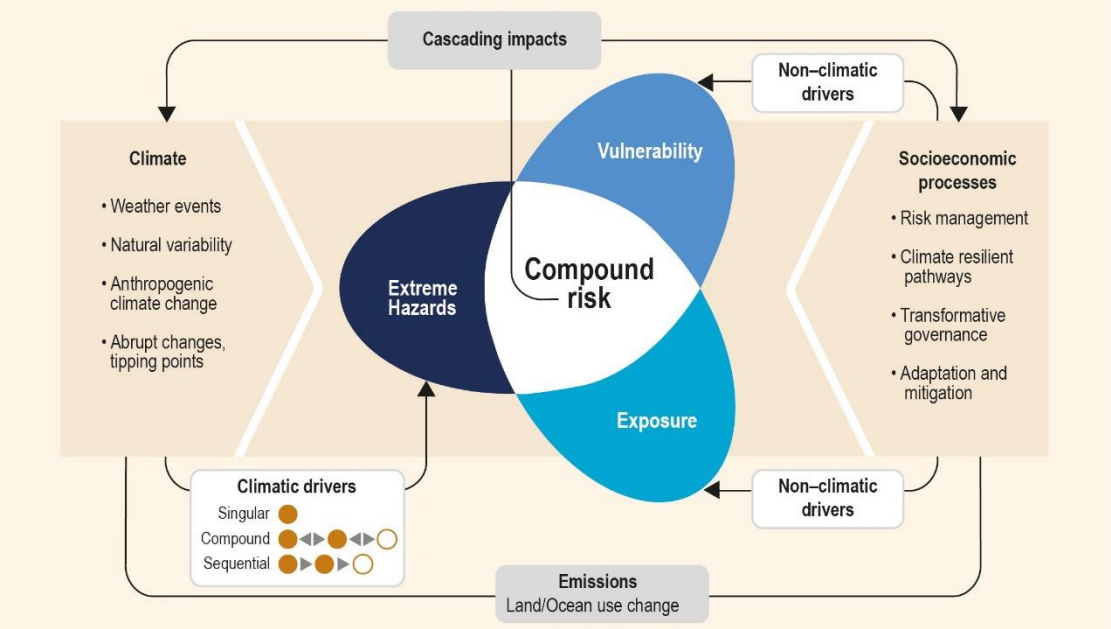

Figure 2: IPCC Risk framework[1]

2.1 Extreme Hazards

For the theme Extreme Hazards the research focus on **achieving a better understanding of river basin response to extreme weather events and climate drivers**. Such an understanding would enable informed decision making of measures to reduce this hazard. These measures can be classified based on their location in:

- Upstream source control measures such as reservoirs, weirs in ditches, vegetation strips, storage and infiltration pools, restoring landscape depressions or microrelief, adapted cultivation of sloped land parcels, reforestation, wetland restoration. These measures aim to control the upstream catchment runoff flows both for floods and droughts;

- Measures in urban areas to reduce the urban runoff drainage, such as stormwater buffer and infiltration basins, infiltration ditches, wadis, bioswales, etc., by cities and municipalities, as well as at industrial parks, in private gardens, and through the use of rainwater tanks and infiltration devices by households. These measures aim to reduce urban runoff into the downstream river system;

[1] https://www.ipcc.ch/srocc/chapter/chapter-6/

- Measures along the river to re-naturalize the riverbed or restore the natural morphological state of the riverbed. For example, re-meandering and removing dikes from rivers in areas where this is still feasible, restoring the historical floodplains, riparian zone restoration. These measures aim to increase or restore the natural storage capacity in the river valley and slow down flood peak propagation;

- Downstream measures along the river, such as controllable weirs, reservoirs, or protection measures like protected / strengthened / increased embankments and dikes. This aims to prevent river flooding in periods of high river discharges.

Many of the above-mentioned measures can be seen as nature-based or blue-green solutions. These solutions have the benefit that next to flood hazard reduction they also help in mitigating the impacts of droughts, erosion, and in some cases even water quality. The measures that involve enhanced infiltration reduce the catchment runoff and increase at the same time the infiltration and groundwater recharge.

Research topic 1 (RT1): effectiveness of (nature-based) solutions

One of the pending and urgent research questions is the effectiveness of such nature-based solutions compared to the more traditional, more end-of-pipe solutions. This effectiveness may depend on the type of event: nature-based solutions may be more effective for less extreme events, so they reduce the frequency of smaller flood events, while downstream grey infrastructure may be more effective for extreme events. This needs further investigations, to come up with recommendations and policy advice for the water authorities.

More specifically, the following research may be undertaken:

- Experimental research on the hydrological response of different types of landscapes, riverbeds, and floodplain configurations;
- Representation of NBS in hydrological and hydraulic simulations;
- Effectiveness of different types of measures including nature-based solutions to mitigate the impacts on climate change on hydrological extremes;
- Characterize catchment resilience and sensitivity to climate change, describing the difference between sites and the impact of geology;
- Describe water movement in the critical zone, estimate runoff components during extreme events, and reconstruct past river conditions.

Research topic 2 (RT2): upstream and downstream measures

The separation between upstream and downstream measures has an extra dimension in transboundary river basins, where upstream and downstream parts of the river basin may be in separate countries or states or administrative regions. Hazard reduction at different locations will be studied in JCAR ATRACE both making use of empirical or experimental data and hydrological models. Different types of hydrological models exist, but it is unclear how they perform in the simulation accuracy of the different types of measures mentioned above, particularly for nature-based solutions.

More specifically, the following research may be undertaken:

- Benchmarking of hydrological models, with a focus on the accuracy to simulate the hydrological impact of extreme weather events, and the impact of different types of measures including nature-based solutions in the headwaters, along the river valley, the contribution of urban runoff and downstream river flow control;
- Improving prediction and modelling of hydraulic impacts of floods through field measurements;
- Comparison of the effectiveness of upstream source control measures vs downstream grey infrastructure. Analysis of the co-benefits of blue-green measures on mitigating floods and droughts;
- River clogging by floating debris: monitoring, cause, formation, backwater effects and consequences of failure.

Research topic 3 (RT3): climate scenarios in flood hazard analysis

Another main research question is on how to deal with climate scenarios in flood hazard analysis. This raises a technical challenge on how to develop plausible extreme boundary conditions, taking the highly uncertain future climate into account. The traditional way of estimating events with given return periods, and after adjusting them based on climate scenarios derived from downscaling an ensemble of climate model outputs, might not be effective under increasing frequency of occurrence of unseen events. Next to the impacts of climate change, the influence of climate oscillations must be accounted for. This requires advanced statistical analysis of long time series of meteorological and river flow conditions. The use of spatial analogues, such as been practiced in 'Water bomb experiments' (very exceptional events which occurred already in other regions of Europe) is another topic of interest to estimate events beyond the local records.

More specifically, the following research may be undertaken:

- Statistical analysis of long-term time series of meteorological and river flow conditions, separating the influence of climate change and natural variability including multidecadal oscillations;
- Study the use of spatial analogues to estimate exceptional events;
- Methods to develop plausible boundary conditions representing very extreme weather events, and how to include climate change;
- Climate change impacts on hydrological extremes;
- Time series analysis of hydrological extremes: trends, multi-decadal oscillations. Development of boundary conditions for hydrological models to study the impact of extreme weather events and climate change.

Research topic 4 (RT4): Forecasting for the future

Next to scenario analysis, another topic of importance in relation to extreme hazards is real-time nowcasting (short term) and forecasting (longer term), as we noted clearly during the July 2021 event. Although meteorological forecasting is a competence of the meteorological institutes, the interaction with hydrological processes needs particular attention, especially regarding the representation of the forecast's ensemble and the propagation of uncertainties.

To obtain this common understanding, the JCAR ATRACE knowledge agenda aims to obtain further insights on these research questions and on the hydrological hazard related to extreme weather events, particularly in the transboundary river basin regions. JCAR ATRACE acknowledges that, due to climate change, the uncertainty on the frequency and magnitude of these weather events has increased. Meanwhile to increase the speed of adaptation society needs understandable and actionable information on the magnitude of the threats.

More specifically, the following research may be undertaken:

- Evaluate nowcasting and timely forecasting of extreme hydrological events;
- Impact forecasting: To develop methods/tools to extend forecasting/early warning from hazard forecasts at points (e.g. flood water stage at river gauge) to distributed impact forecasts (e.g. inundation areas, possible impacts on humans and assets).
- How to come from uncertain forecasts to actionable decision information (warning levels and actions)
- Integrated fluvial and pluvial flood modelling.

2.2 Exposure

Next to the severity of the event, the amount of damage and casualties inflicted by an extreme weather event also depends on the extent to which people, economic assets and ecosystems are exposed to the event. Commitment to developing transboundary river basin management for flood and drought management benefits from a **better common understanding of the changes in exposed people and assets to extreme climate drivers over an entire river basin.** JCAR ATRACE will support the development of a common exposure database that is used by all partners and can be used for further research.

There are three main challenges related to developing such exposure databases needed for flood and drought risk assessment: (1) the lack of consistent high-resolution data on (socio-economic) characteristics of assets and people (2) the lack of consistent high-resolution data of critical functions and infrastructure and (3) the lack of (future-) exposure projections. An essential question related to these data is also on how to keep these data up-to-date in the longer term.

Research topic 1 (RT1): consistent high-resolution data on (socio-economic) characteristics of assets and people

Efforts to characterize the built environment and land use exposed to floods and drought are often based on housing and population censuses, cadastral data and maps, and local field surveys. These traditional approaches have several limitations in terms of update frequency, spatial coverage and resolution, information depth, and costs due largely to our rapidly changing and tightly interconnected world. However, new data sources, e.g., social media and crowdsourced data such as OpenStreetMap, provide information about building attributes and land use/cover. In addition, novel earth observation (EO) data analysis may characterize different features of the natural and built environment. For example, EO-based digital elevation models (DEMs) have reached a level of accuracy that can be employed to determine the height and other characteristics of human-made structures (e.g., buildings, bridges, infrastructure), an attribute that is critical to classify building vulnerability against storms and earthquakes.

More specifically, the following research may be undertaken:

- High-resolution mapping of the built environment using a uniform approach;
- Evaluation of methods to assess flood and drought losses;
- Benchmarking of impact and losses models using new exposure data;

- Develop a consistent data base on exposure for transboundary basins;

Research topic 2 (RT2): consistent high-resolution data of critical infrastructure

Mapping exposed critical infrastructure is important to assess flood and drought risk in an area. This not only pertains to the direct damage but also the indirect (economic) losses resulting from cascading effects. These infrastructures may include for example power stations, telecommunication stations, roads and railway lines, bridges, drinking water production facilities, and wastewater treatment plants.

More specifically, the following research may be undertaken:

- Map the exposed networks of critical infrastructure;

Research topic 3 (RT3): future exposure projections

Future projections of exposure and, for example, urbanization in flood plains is important to assess potential flood risk in the future. Here population projections from the SSPs or simulation from land use models can be used as estimates for future exposure. For drought risk, the change in population or economic sectors and their water demand is relevant for estimating water deficit based on future supply and demands.

More specifically, the following research may be undertaken:

- Develop future projections of asset and people exposure;
- Develop scenarios of relevance for flood and drought management (e.g., future water demand in various sectors).

2.3 Vulnerability

Vulnerability to floods and droughts is the least understood driver of risk. Vulnerability can change substantially in time, and it is often much more volatile than hazard and exposure. Current research focuses on assessing which drivers contribute to vulnerability. For assets, these factors are related to physical characteristics and how assets are maintained or constructed. The vulnerability of people (social vulnerability) is related to demographics (age, gender), economic, institutional, and environmental drivers. Social vulnerability has an influence on the adaptive capacity of people and thus on physical vulnerability. A recent research challenge is to assess how both social- and physical vulnerability varies over space and time (i.e., into the future).

Research topic 1 (RT1): Vulnerability of buildings
For buildings, vulnerability depends, for example, on the material of the buildings or whether the building is elevated above expected flood water levels. Currently, the assessment of flood vulnerability is often based using simple flood-depth damage curves. However, recent research using ML (e.g. Bayesian networks) include multiple factors from e.g. surveys and show it is possible to improve vulnerability models.

More specifically, the following research may be undertaken:

- Improve flood vulnerability and damage estimates of assets;

Research topic 2 (RT2): Vulnerability of infrastructure
Infrastructure is a special class of assets that are exposed to flooding. When determining the vulnerability of infrastructure, both direct damage and in-direct damage play a role. For example, if a communication hub is being hit by a flood, other communication lines (outside the flooded area) may also be affected through cascading effects. Other research shows that when roads are flooded, emergency services may not provide their first responses task. JCAR may investigate how flooding affects these direct and in-direct effects by, for example, combing flood risk models with network models. Or, by using machine learning methods to assess cascading impacts patterns from flooding through connected networks.

Research topic 3 (RT3): Social vulnerability
The vulnerability of people in areas prone to floods and droughts is dependent on socio economic factors, such as demographic characteristics (e.g., age), education, income, gender, etc. Studies have tried to characterize vulnerability using aggregated indices, but these simulations are quite coarse, and do not find robust relations between the level of

vulnerability and the expected impacts from floods and droughts. JCAR may enhance vulnerability assessment by collecting high-resolution socio-economic data from different countries using e.g., CENSUS data, to create a common database on socio economic characteristics.

More specifically, the following research may be undertaken:

- Develop a historical re-analysis database of socio vulnerability and asset vulnerability;
- Assess the drivers of socio-vulnerability of households;
- Socio-economic factors driving flood risk;
- Role of insurance in flood risk management.

Research topic 4 (RT4): Vulnerability and DRM

The vulnerability of people and assets to floods and drought is dependent on how much people can apply Disaster Risk Reduction Measures (DRM) or have access to financial compensation schemes (e.g., through insurance). Whether a household implements DRM is dependent on the above-mentioned vulnerability factors (income, education, etc.). However, also psychological factors (e.g., risk perception) play an important role. For example, cognitive biases such as risk perception have played an important role in past flood disasters and have catalyzed adaptation after a major disaster with numerous fatalities took place.

More specifically, the following research may be undertaken:

- Assess how the drivers of vulnerability lead to more or less adaptation;
- How do people and governments react to extremes;
- Spatial analysis of vulnerability indicators.

Research topic 5 (RT5) Equity

Recent research shows that the most vulnerability communities are disproportionately hit by flood and drought events. Using vulnerability assessment and assessing the spatial-temporal drivers of vulnerability may support locating the most vulnerable people and support policies to decrease inequity.

More specifically, the following research may be undertaken:

- Map hotspots of flood vulnerability of most vulnerable communities;
- Transboundary policies/institutions to increase individual-based climate resilience.

2.4 Compound Risk and adaptation measures

In response to the severe floods and droughts over the last few years, a wide range of possible measures and strategies have been proposed in the different countries to cope with these events. The call for adequate measures to avoid severe consequences is amplified by an increasing awareness that the intensity of both dry and wet hydroclimatic events will increase due to climatic change. In brief, what we consider as an extreme event under the prevailing conditions may very well become a common condition in the near future. What, when and how proposed measures will be realized will vary between the countries. Not in the least because different perspectives exist on what type of strategies are the most appropriate. Yet, no extensive research has been undertaken about the river basin wide consequences of different measures and strategies, how these perform under opposing (dry-wet) extreme conditions as well as what (transboundary) performance and consequences on the longer term can be expected. Therefore, JCAR ATRACE will perform research on the following issues related to adaptation solutions:

- Stress testing: how effective are the current plans and measures under future extremes and how can we prepare for extremes?
- What transboundary consequences can be expected from the measures proposed in the evaluation studies?
- The applicability of approaches to mitigate undesired consequences of extreme events that strongly lean upon the assumption that the natural system is knowable: we know the extent, probabilities and consequences of extreme weather (e.g., the Dutch Risk approach). However, knowledge is often based on short historical timeseries, and extrapolating them to the future is linked with much uncertainty.
- The applicability of approaches that lean upon the perspective to manage the most adverse consequences and accept minor consequences of extreme events.
- A comparison of different advice on the preparation for extreme hydroclimatic events

Solutions can be focused on prevention of the hazard, to reduce the exposure and the vulnerability. In this theme, research will focus on adaptation options for both flood and drought risk, and with special focus on extreme weather conditions.

Research topic 1 (RT1): Stress testing and assessing effective measures to reduce the hazard

This research will address one or more of the following topics:

- To assess the effectiveness of current plans and measures under future extreme events
- The effectivity of nature-based solutions in reducing flood and drought hazards;
- Effectivity and adaptability of grey infrastructure to reduce the hazard from floods and droughts;
- Cross-bordering assessment of reservoir management on flood events;
- Testing the advice formulated in the "weerbaar waterland" report for Flanders, be preference on a transboundary basin and compare methodologies and stress testing approaches and results.
- What are the minimal goals to reach acceptable flood and drought risks at basin scale.

Research topic 2 (RT2): effective measures to reduce the exposure and vulnerability (consequences)

Research to measures that effectively limit the adverse consequences of floods and droughts via reducing the exposure and vulnerability will include:

- Spatial planning in flood-and drought prone areas;
- Building codes;
- Effect of flood insurance on urban development;
- Drought tolerant land use;
- Water priority ladder for regional river basin;
- Public awareness campaigns;
- Flood early warning and transboundary emergency response;
- Recovery capacity.

More specifically, the following research may be undertaken:

- Assessing cost and benefits of adaptation (both households and government);
- Assessing if policies (insurance, government) have effect on household adaptation and flood risk;
- Development of storylines for extreme events;
- HILP (High-Impact / Low-Probability events): To develop events that have very low probability but high impacts. This should include not only the hazard part, but also the impacts (e.g. failure of safety measures, societal response, failure of critical infrastructure);

- Changes in flood and drought risk: To understand past changes and to develop possible future changes; again, covering all risk components;

2.5 Technology development

For assessing the local or regional impact of extreme weather events the interest is typical on events that are extremely rare or even unprecedented. Inevitably we have few recent local and regional examples and therefore to quantify the impact of these events we need to rely on computational models. Numerous impact models for water (flood and drought) management have been developed over the past decades. These models vary in the way they represent the processes that determine the hydrological response, river flow, water levels on extreme weather. Also, various computational models exist to transfer the hazard, flood, and drought, into consequences, the damage. Due to the character of extreme events, opportunities to validate model chains that describe these impacts are limited. Since these models vary, the resulting damage assessments may heavily depend on model choice. A similar situation exists for assessing potential measures that mitigate unwanted consequences. The assessment of their performance depends heavily on the way the measures are represented in the computational models. Regarding nature-based measures to mitigate high and low-water risks, this is even more the case. Our understanding of the effectiveness of these measures is limited, and thus, our ability to quantify them is constrained.

Climate scientists approach this problem with massive model comparison studies, recently resulting in CMIP6, the sixth generation of these comparisons. Despite the existence of very diverse impact models, there are few impact studies in water management in which different models are compared with each other. Unfortunately, the commonly applied approach is to select a model which happens to be available, or what people are used to. This may result in a situation where modelers in upstream parts of the basins use other models than flood modelers on the downstream side of the border.

Research topic 1 (RT1): Comparison of impact models
JCAR ATRACE aims at developing a common computational framework that will enable accessibility to different impact models that simulate both or flood and drought hazards, exposure, and vulnerability in each sector of interest (e.g., agriculture, water resources, tourism, forestry, or

biodiversity) assuming specified changes in key driving variables (climatic and/or socio-economic) in the transboundary basins.

More specifically, the following research may be undertaken:

- Comparison and standardization in models / approaches across the countries

Research topic 2 (RT2) Developing/adjust models to assess the effects of responses

JCAR will advance on the impact models by developing models that can simulate the effect and/or effectiveness of adaptation responses including ecosystem-based approaches. Sectoral models are typically the same sectoral impact models applied in impact and risk assessments but with capabilities to represent alternative adaptation measures, often described as management assumptions. For example, models might simulate the impact of flooding on urban areas with and without flood protection measures, to evaluate the flood damage avoided by protection under alternative scenarios for extreme weather events, as well as analyze the performance under extreme dry conditions.

More specifically, the following research may be undertaken:

- Towards a transboundary accepted and calibrated flood impact model, across the EMR (and beyond?)
- Dynamic adaptation over time and space (Agent based models)
- Consistent regional flood risk modelling

Research topic 3 (RT3) Developing integrated assessment models for decision making

JCAR aims at tools that package together alternative models and analytical methods, based on and often simplified from those described for the previous groups, to support decision making across a range of alternative circumstances and requirements. Decision-makers might adopt such tools, for example, in basins where no prior model-based assessments are available, for addressing high degrees of future uncertainty or for comparing the effectiveness of different identified adaptation strategies. Examples of such frameworks that will function for inspiration are the OpenCLIM Framework[6] and the Dynamic Adaptative Policy Pathways (DAPP)[7].

More specifically, the following research may be undertaken:

- Developing models, instruments for risk management;
- The representation of the nature-based solutions in numerical models;
- Integrate models in a common framework;

2.6 Knowledge gaps according to the competent authorities

During 2023 the JCAR ATRACE partners made an inventory of research interests from the competent authorities. The questions were obtained at various meetings including the interviews for the development of the scoping basin reports, the Benelux water day, meetings of existing transboundary platforms such as the GPRW and the evaluation reports of the extreme floods in 2021. A long list of the topics proposed in different meetings can be found in the list of potential RAT studies published in the annex.

By evaluating the topics proposed in view the scope of JCAR ATRACE we arrived at the following overarching research topics:

- Research focusing on transboundary forecasting and warning systems for extreme events (Extreme hazards), including effective common crisis communication (Vulnerability);
- Research focusing on the effectivity of the 'sponge effect' in basins in acting to prevent floods and droughts;
- Research that evaluates the transboundary consequences (upstream-downstream) which can be expected from the measures proposed in the evaluation studies?
- Research that provides assessments on the current state of research, data and information in the different basins;
- Research efforts will address to arrive at a common language to understand flood and drought risk particularly on the topic's exposure and vulnerability and proper management.
- Activities will be undertaken to develop common technologies to quantify flood and drought risk both for operational, forecasting, purposes as well as for strategy design.

In addition, a substantial number of research questions were identified that can be categorized under the topic "governance" of the waters in the river basins. The proposed topics focus on the question of *how* we could become better prepared for these extreme events, assuming that we know *what* to do. Examples of the proposed topics are:

- How can international cooperation between competent authorities be improved within the existing mandates and responsibilities of these authorities?
- Which governance structures need to be broken up to optimise cross-border cooperation for water management?

- How to achieve international agreements for crisis situations regarding scaling –up, congruent methods and models?

To a certain extent these questions are addressed by JCAR under the themes *vulnerability* and *compound risk and adaptation measures.* However, the current knowledge agenda as published above may need to be expanded to address the full range of governance questions. This will be discussed further in relation to specific river basins.

2.7 Study sites: regional river basins

Research and studies will be executed a.o. in the following regional river basins:

A. Vecht-Achterhoek (Delta-Rhein-Ost)
These include the Oude IJssel, Aa-strang, Boven-Slinge, Beurzerbeek, Berkel, Buurserbeek and Overijsselse Vecht and Dinkel regional rivers. These rivers drain into the IJssel branch of the river Rhine in the Netherlands.

B. Limburg – Nord-Rhein Westfalia (Maas-Nord and Maas-Süd)
These include the Roer, Niers, Swalm and Geleenbeek regional rivers. All rivers are tributaries of the river Meuse in the Netherlands.

C. Limburg – Belgium (Maasbekken)
These include the Geul, Voer, Jeker, Thornerbeek and Uffelschebeek regional rivers. All rivers are tributaries of the river Meuse in the Netherlands.

D. North-Brabant – Flanders (Maasbekken)
These include the Watermolenbeek, Aa of Weerijs, Boven-Mark, de Dommel and Tongelreep regional rivers. The rivers are tributaries of the Meuse and Scheldt river in the Netherlands.

In addition to research in the above-mentioned cross-border regions of the Netherlands and neighbouring countries, comparable or other research questions are applicable to regional river basins in the Benelux, Nord-Rhein Westfalia, Niedersachsen and potentially Northern France. These will be selected during JCAR ATRACE implementation.

3 Knowledge organisation

3.1 Roles and responsibilities

The main roles and responsibilities of entities related to JCAR ATRACE are described in chapter 5.1 of the programme plan.

To operationalize the research activities in JCAR ATRACE, two main programme management entities are in control: the scientific programme council (SPC) and the operational management team (OMT), lead by the programme manager.

The scientific programme council (SPC):
The scientific programme council (SPC) consists of international researchers from all transboundary countries and is responsible for the scientific quality of the research conducted in JCAR ATRACE. The council will provide guidance on topics selected for research and together with its members will be responsible for supervising the research and all applied scientific research activities. One of their main tasks is to design and implement the knowledge agenda. The chair and the secretary of the SPC are responsible for coordinating the input, setting up and updating the document.

Programme Manager (operational management team):
The programme manager and the OMT will coordinate and actively pursue the communication of the knowledge agenda on a daily basis to the relevant stakeholders and researchers. Further, as the (annual) available budget and capacity is limited, the OMT and programme manager need to prioritize the research in coordination with the SPC and provide the budgets.

This knowledge agenda will be the guiding document to be discussed on strategic directions with the stakeholder advisory board and external scientific review group. In 2024 a first meeting is planned to be held; it is suggested but still to be decided whether the stakeholder advisory board and external scientific review group may be combined into **one** (policy) advisory board. The concrete research activities and studies will be executed as much as possible in tailored co-creation with knowledge clients: relevant regional competent authorities, existing regional transboundary cooperation platforms and/or stakeholders.

3.2 Input sources of policy-relevant research topics

The knowledge agenda is a 'living' document, which will evolve during the duration of the JCAR ATRACE programme. Input to the knowledge agenda will come through three main channels:

1. **Scientific Programme Council:** The scientific council, as the owner of the knowledge agenda, formulates the research questions and topics, which will be mainly pursued by (PHD-) students and staff from the JCAR ATRACE institutes.
2. **River Basin Fora:** As part of the state of the basin's and scoping studies, interviews will be conducted with the competent authorities and stakeholders in the basins to collect policy-relevant knowledge questions. Additionally, coordinated meetings with existing basin platforms will be used to identify local and regional knowledge questions.
3. **Other:**
    a. Institutes will engage *regularly* with their competent authorities (incl. national governments) through bi-or multilateral meetings and collect information about policy-relevant research questions.
    b. JCAR ATRACE will support and attend official (government) meetings (e.g., Benelux Waterday, expert meetings).
    c. JCAR- ATRACE will engage with competent authorities through research on recent events (other countries in Europe).

Detailed overviews of the events and meetings organized and/or participated by JCAR ATRACE will be provided in the annual plans and updated on the external website.

As the number of research questions and topics will quickly grow exponentially, and beyond the capabilities of this first phase JCAR ATRACE programme, a careful selection and prioritization planning process is needed. This means by principle that not all identified research topics can be adopted (directly) within JCAR ATRACE. JCAR ATRACE institutes may help to support regional governments to look for further/other opportunities in execution.

3.3 Planning process of research activities

Policy-relevant research activities in JCAR will be executed within the two main pillars, basically by two main modes of research: rapid action team studies (length 2 months – 1 year) and scientific research activities, including capacity building and teaching (see section 3.4).

3.3.1 PhD and MSc-research

The long-term scientific research activities will centre around joint PhD-research, MSc-research and other educational activities (see section 3.4). These activities will always be related to the scope of research and policy-relevant research topics, defined in this knowledge agenda. The actual lists of draft PhD- and MSc proposals and topics are stored on the internal sharepoint. Within JCAR ATRACE there is budget allocated to 8 joint PhD research positions. Joint MSc research is another cornerstone of research activities in the programme. Topics can be defined, following a specific format and advertised through the normal channels of the institutes. Potentially the external website could also play a role here in the future.

3.3.2 Rapid action team (RAT-) studies

The rapid action team (RAT-) studies are annually planned, and new RAT study proposals are evaluated at least twice a year (Q4 for next year studies, Q2 for second half of year studies). Each RAT-study proposal needs to go (at least once) through a 3-step approach before it can be approved for execution: definition-verification-prioritization

- **Step 1: definition** by JCAR ATRACE institutes, in co-creation with competent authorities;
- **Step 2: verification** by operational management team/programme manager;
- **Step 3: prioritization and approval** by operational management team/programme manager, in coordination with / counselled by SPC;
- **Step 4: initiation and progress** of a RAT study is coordinated by a RAT study leader (RAL), who reports to the OMT and SPC. RAT studies typically follow an open research process with participation and consultation via focus or advisory group meetings.

Figure 3 Generic planning process of Rapid action Team studies

Step 1: definition

Based on a simple format, a RAT study can be defined by one or more JCAR ATRACE institutes. It should be policy-relevant and based on request or interest of (regional) competent authorities or stakeholders (river basin for a) and be part of the scope of research (see Overview_RAT_studies.xlsx). Prior and close communication with (focal points) of the river basin fora is considered important. The draft RAT study proposal is sent to the OMT for the verification step.

Step 2: verification

The OMT and programme manager verifies whether the drafted RAT study matches the knowledge agenda scope, scientific interest, it is connected to a request/interest from competent authorities/existing cooperation platform, it is transboundary and whether it is a joint cooperation between institutes. If not sufficiently clear, the drafted RAT study will be returned with the request for adaptation.

Step 3: prioritization and approval

If all criteria are sufficiently met, the OMT will put the RAT study on the SPC agenda to be acknowledged for approval. Dependent on urgency, available time, budget and capacity (checked by the OMT), the start of the RAT study will be planned right away, may be phased or delayed. A RAT study leader (RAL) will be appointed. PhD-researchers, MSc-researchers and research staff of the JCAR ATRACE institutes can be part of the team of the RAT-studies. Further, the team may be extended with additional expertise from other knowledge institutes or consultants, if necessary.

Step 4: initiation and progress

Initiation of (new) RAT-studies will be timely reported to the contact person of the grant provider (Ministry of Infrastructure and Water) by the OMT/Programme Manager. Starting and progress of RAT-studies will be communicated to the relevant authorities and stakeholders (river basin fora) via our main communication channels. Further, river basin fora will be requested as knowledge client to participate and be consulted, if relevant and necessary, via one or more dedicated focus, information or advisory group meetings. The RAL reports to the OMT and SPC.

3.4 Capacity Building and Teaching

The JCAR ATRACE consortium includes several international partners from the Netherlands, Belgium, Germany and Luxembourg. A close collaboration between all institutions and partners is a key aspect of this innovative programme, which means that cooperation and partnership among participants will be encouraged and supported throughout the programme.

The main goal of the programme is supported by achieving the following objectives:

- **Building a scientific JCAR ATRACE community:** strengthening the scientific community around transboundary river basins through joint research and education and exchange of knowledge.
- **Enhance scientific quality:** To share, discuss, and communicate collective scientific JCAR ATRACE output to improve scientific quality and peer review.
- **Connect and involve stakeholders:** To develop, share and discuss scientific development with the professional community and policy makers.

The three objectives tie together within two overarching themes: research and education. The activities to meet these objectives are described in detail in the JCAR knowledge sharing and expert community plan.

This will be ensured through the main following research and educational activities:

- Organization of a knowledge platform – Bi-annual gatherings
- Hackathons / RAT-studies
- Frequent online PhD meetings
- Data exchange
- Presence at existing conferences, symposia, or other events
- Co-supervision of PhD students

- Co-supervision of MSc students
- Align field work activities
- Involve PhD students in JCAR ATRACE-related education activities
- Involve JCAR ATRACE partners in existing courses and programs
- Joint JCAR Summer school and trainings

3.5 Updates

The Knowledge Agenda is a 'living' document and will evolve with the JCAR ATRACE programme. Policy-relevant research questions will be collected continuously and added to the shared list. The knowledge agenda will be updated annually as part of the annual plan. It may be considered to publish the knowledge agenda at our website and maintain changes there on a regular basis.

Annex

Joint PHD proposals

Topic (institutes)	Status
1. Understanding and preparing for High-Impact / Low-Probability (HILP) flood events (Lead: GFZ)	Draft
2. Using experimental catchment data and machine learning to benchmark hydrological models for hydrological extremes (Lead: LIST)	Draft
3. Testing the implementation of the Weerbaar Waterland recommendations in transboundary river basins (Lead: KU Leuven)	Preliminary
4. Reservoir operation under a changing future (Lead: RWTH Aachen)	Draft
5. Impacts of hydrological hazards in the business sector (Lead: Université de Liège)	Draft
6. Towards better monitoring and modelling approaches to assess the impacts of floods on infrastructure (Lead: TU Delft)	Draft
7. Assessing trade-offs between early action and long-term flood adaptation under climate- and socio-economic change (Lead: VU Amsterdam)	Draft
8. To what extent and under what conditions do various collaboration mechanisms (research, political, etc.) contribute to improved flood and drought risk management? (Lead: University of Twente)	Preliminary

Deltares will have a supporting role as an external organization in all the PhD trajectories, to a more or lesser extent, but we are not a university.

This table and more detailed information can be found on the programme sharepoint. Once finalized, it will be published on our external website.

Research topics for RAT-studies

This is a dynamic large table of research topics that will be stored and updated at the programme's sharepoint. The topics will be discussed with the knowledge clients and when a RAT-study commences will be published on the external website.

MSc Thesis Proposals

Topic (institutes)	Status
1. **Technology:** Multi-model comparisons in river flow forecasting (Deltares)	Draft
2. **Vulnerability:** Representation of exposure and vulnerability in risk assessments (VU Amsterdam, Twente University, Deltares, …)	Draft
3. **Extreme hazards:** Representation of nature-based solutions in hydrological models (VU Amsterdam, Twente University, Deltares)	Started January'24
4. **Extreme hazards:** Identifying extreme weather events from ensemble weather prediction archives (Deltares, Twente University, GFZ Potsdam, KU Leuven, …)	Draft
5. **Technology:** Machine learning and rainfall runoff modelling (Deltares, LIST, …)	Draft
6. **Compound risk and solutions:** Hydraulic study: focus on rivers, flood risk and failure mechanisms/measures in the Rur river basin (TU Delft, RWTH Aachen, Deltares)	Idea March'24
Etc.	

This table and more detailed information can be found on the programme sharepoint. Once a topic is defined, it will be advertised on institutes' websites. MSc theses results will be published on our external website.