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DALIA DANUBE LIGHTHOUSE

D.2.1. DALIA tool – Database of associated regions and tools for analysis

DALIA
DANUBE REGION
WATER LIGHTHOUSE ACTION

Grant Agreement Number: 101094070

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2.0	July 17, 2024	Ullmann V., Borgs T., Chappon M.	Review comments and edit

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LIST OF ABBREVIATIONS

Abbreviation	Full name
SDM	Structured Decision Making
VFT	Value Focused Thinking
FFT	Fast and Frugal Tree
SCT	Social Choice Theory Systems
DPS	Demonstration Pilot Site

EXECUTIVE SUMMARY

According to the grant agreement the ***deliverable D2.1.-DALIA tool: Database of associated regions and tools for analysis*** *will be used for assessment of associated regions and their relevance for concrete transfer.* Also, specific objectives 2.1 was to *Develop a methodology for socio-economic, environmental, and water conditions assessment of regions in the Danube river basin*. However, it was concluded that the analysis should not be limited to regions within the Danube River Basin, but should encompass all eligible regions. Consequently, it was recommended that the DALIA tool should:

a) Define a set of indicators, for comparisons of regions which will include environmental condition indicators and socio-economic condition indicators.
b) Collect relevant data about regions.
c) Define a methodology for region comparisons.
d) Select a list of candidate regions for transferring experiences.

For that purpose, we proposed an approach that combines *Structured Decision Making (SDM), Value Focused Thinking (VFT), Fast and Frugal Tree (FFT),* and *Social Choice Theory Systems (SCT)*. In Phase A, *SDM* and *VFT* are used to frame and structure the decision-making problem to collect all relevant data for the assessment of associated regions. For this purpose, the Dalia Tool Questionnaire was created. This was done in a group context where representatives of all demonstration pilot sites participated by answering the Dalia Tool Questionnaire. After that, in Phase B, a database of associated regions was created. Using data from Phases A and B, the *FFT* was created and used for the assessment of associated regions and their relevance for concrete transfer in Phase C. Finally, in Phase D, the results obtained with the FFT were combined with *Borda count* and *Approval voting* to obtain rankings of associated regions.

For future work, obtaining more precise data on the associated regions would enhance the robustness of the analysis.

In addition, a key outcome of the Dalia Tool Questionnaire is the identification of key activities from demonstration pilot sites for potential replications, which are outlined in table below:

DPS	Pilot Site Entity	Problem	Solution	Potential Replication	Type of activity to be Replicated
DPS 1	Széchenyi István University, Győr, Hungary	Heavily modified water bodies (HMWB) due to: - River Regulation, - Floodplain reduction, - Riverbed incision, - Diversion Canal Hydropower Plant	Design, construction and operation of a dynamically controlled water replenishment system on the active and historical floodplains. Involving stakeholders in design and operation decision making processes. Longitudinal and lateral connectivity of river branch systems.	1) designing water body and wildlife habitat rehabilitation 2) stakeholder involvement practices during planning and operation 3) dynamic control of the system 4) design aspects of artificial habitat development and different fish passes	- Revitalisation of ecological systems - Ecosystem monitoring and restoration - Reconnection of floodplains - River connectivity - River rehydration
DPS 2	Catholic University of Eichstätt-Ingolstadt, Germany	Heavily modified water bodies (HMWB) due to: - River Regulation - Floodplain reduction - Riverbed incision - Hydropower Plant (transversal structure) - Lost of longitudinal and lateral connectivity	Floodplain re-connection by technical re-establishment of hydrologic dynamics and restoring of ecological functions: 1) Construction of a eight-kilometre-long bypass stream to restore the longitudinal and lateral connectivity 2) Controlled small floods to mimic natural floodplain dynamics	1) Construction of a (controlled) bypass stream 2) Controlled small floods 3) Groundwater lowering 4) Abiotic Monitoring: Hydrology (groundwater level, discharge, soil moisture), Erosion (remote sense data) 5) Biotic Monitoring: Vegetation (macrophytes, riverbank vegetation,	- Revitalisation of ecological systems - Ecosystem monitoring and restoration - Reconnection of floodplains - River connectivity

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			3) Groundwater lowering to increase groundwater fluctuations	forest vegetation), Seeds (neophytes, floodplain vegetation), Amphibians	
DPS 3	T.G. Masaryk Water Resources Institute, Prague, Czech Republic	The area is transitioning into a large, protected floodplain forest, heavily utilizing its water resources for various activities such as industry and conservation. The management involves complex water control systems like weirs and dikes. This forest depends on periodic artificial flooding from a reservoir to maintain its ecosystem. With climate change causing higher evaporation and unchanged precipitation levels, managing water effectively is becoming increasingly challenging in maintaining the area's hydrological balance.	Monitor and Research: Continuously monitor water and weather conditions and conduct research to better understand local impacts of climate change on water resources.	1) Evaporimeter station 2) Reba Tor (Reservoir Balance Calculator)	1) Clarification of evaporation from the water surface by means of a floating evaporimeter 2) The calculation of the reservoir balance which includes not only inflow, minimum residual flow below the reservoir (MRF), and withdrawal but also evaporation from the surface and precipitation onto the surface.
DPS 4	People and Water NGO, Kosice, Slovakia	The Slovak experiment documents the impact of the landscape structure revitalization nature-based measures with retention capacity increase on improving water resources and moderating flash flood risks. To create a network of partners in EU countries who would start the implementation of the methodology of integrated rainwater management in order to connect the needs of water, soil, ecosystem, and climate protection in entire basins. The goal is to include the integrated rainwater management in the plans of integrated management of river basins, so that rainwater, which currently brings risks, becomes a co-creator of increasing economic benefits in the river basin in accordance with the need for permanent regeneration of water resources and soil, strengthening biodiversity and healing the climate.	There are 2 possibilities for replication from the Slovak project. The first option is obtaining water resources by increasing the water-holding capacity of damaged ecosystems in the forest-agricultural landscape through NBS. The second replication, which results from Slovak research, is the development of action plans for basins in which the potential possibility of using rainwater to solve water security for people, food, nature, and the climate is defined.	In the damaged drainage area of 25-50 hectares, implement water retention measures to collect rainwater, which will strengthen percolation into the soil and will supplement the replenishment of soil and groundwater supplies with the subsequent restoration of the depleted groundwater sources of springs. It follows from the preparation Slovakia that it is possible to stop the growth of floods by implementing the entire network of the natural based solutions (NBS), to strengthen the abundance of water resources in the territories, to improve the hydrology of water courses, to improve the fertility of the forestry and agricultural landscape by depositing carbon in ecosystems and soil, to eliminate heat islands over an urbanized landscape, to reduce health risks from overheating the landscape.	Two types of activities according to the interest of the replicators. 1) Processing the potential of obtaining water resources through the NBS, preparation, design, implementation, and monitoring of the impact of the NBS on the hydrology of small watercourses 2) Analyses of the damage to the forest-agricultural and urbanized landscape for the water balance, the proposal of solutions for the restoration of the damaged landscape with the quantification of the benefits, for water resources, soil fertility, forests, the temperature regime of the landscape and carbon sequestration.
DPS 5	University of Novi Sad, Faculty of Agriculture, Serbia	Water quality issues caused by wastewater.	Constructed Wetland System (CWS) for wastewater treatment. They are engineering methods that are designed and built using natural and regular processes that include active ingredients such as vegetation, soils, plant extracts, algae extracts, fungi, and bacteria that are effective in the wetland to assist with wastewater treatment.	1) Designing CWS 2) Part or all of the construction and installation works for CWS, subject to available financing	- Revitalisation of ecological systems - Ecosystem monitoring and restoration
DPS 7	National Institute of Hydrology and Water Management, Romania. Lower Danube University of Galati Romania	Decreasing of suspended sediment transport into the Black Sea and river dredging for navigation purposes are main issues that require better knowledge of suspended sediment load transported by the Danube into the Black Sea, as well as knowledge of sediment quality along the river.	Purchase, installation and use of the continuous monitoring station, containing 5 sensors, to be placed at the mouth of the river, before discharged into the seas/ocean, in order to improve the suspended sediment monitoring. Through the use of historical data and the collection of seasonal and time series data, the resulting database will provide all that is necessary for the development of highly accurate virtual sensors for sediment monitoring. In the same time prediction and forecasting models related to both water quality matrix and sediments, developed on the base of neural network approach can be used for better knowledge of sediment quality.	1) Designing of field campaign to estimate the evolution of suspended sediment budget along the river and the sediment quality 2) Part or all of the construction and installation of the continuous monitoring station 3) Prediction and forecasting models related to both water quality matrix and sediments 4) Guide for deep-learning based framework to develop a more complex monitoring system for physic-chemical parameters	- Sediment management activities – Ecosystem monitoring and restoration
DPS 8	Plastic Cup Society, Hungary	Plastic pollution of rivers: lack of tools and protocols to learn and manage the problem, lack of awareness raising tools and lack of joint responsibility of local people towards the river.	Based on the 10+ years' experience of Plastic Cup, the Riversaver Replication Pack consists of know-how and protocols about organising river monitoring (data management), pollution management (cleanups) and awareness raising. The Riversaver Replication Pack is based on knowledge sharing, involvement and education of local stakeholders and citizen science.	1) Tools (boat, river litter skimmer) and protocols for management of transnational riverine litter (plastic) pollution 2) Tools (River Litter Lab) and protocols for awareness raising (incl. Communication and education) about plastic pollution in rivers 3) Tools (GPS bottle, remote sensing) and protocols for data collection and management (harmonised plastic pollution monitoring in rivers)	- Litter clean up in rivers and connecting ecosystems - Ecosystem monitoring and restoration - Revitalisation of ecological systems

DPS 9	Crisuri Water Basin Administratio n	Pollution of rivers with PET bottles and other floating materials.	Implementation of intervention sections by placing three litter traps in the cross-border zone of three main streams.	Physical replication: one intervention section. Non-physical replication: A study about some (or all) rivers situated in a given hydrographic basin (or more) to identify problems related to floating waste and such other materials that end up in their respective riverbeds and could possibly transfer to other countries and/or territories, or even in seas and oceans. This study could branch and go in-depth, considering aspects like where/what/why/how and in the end should offer at least two physical or non-physical solutions, a proposed methodology for further implementation (if needed), regarding a way of reducing or even denying floating waste disposal in the studied rivers, considering the legislation of that country.	- Litter clean up in rivers and connecting ecosystems

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TABLE OF CONTENTS

1. THEORETICAL PART OF DALIA TOOL

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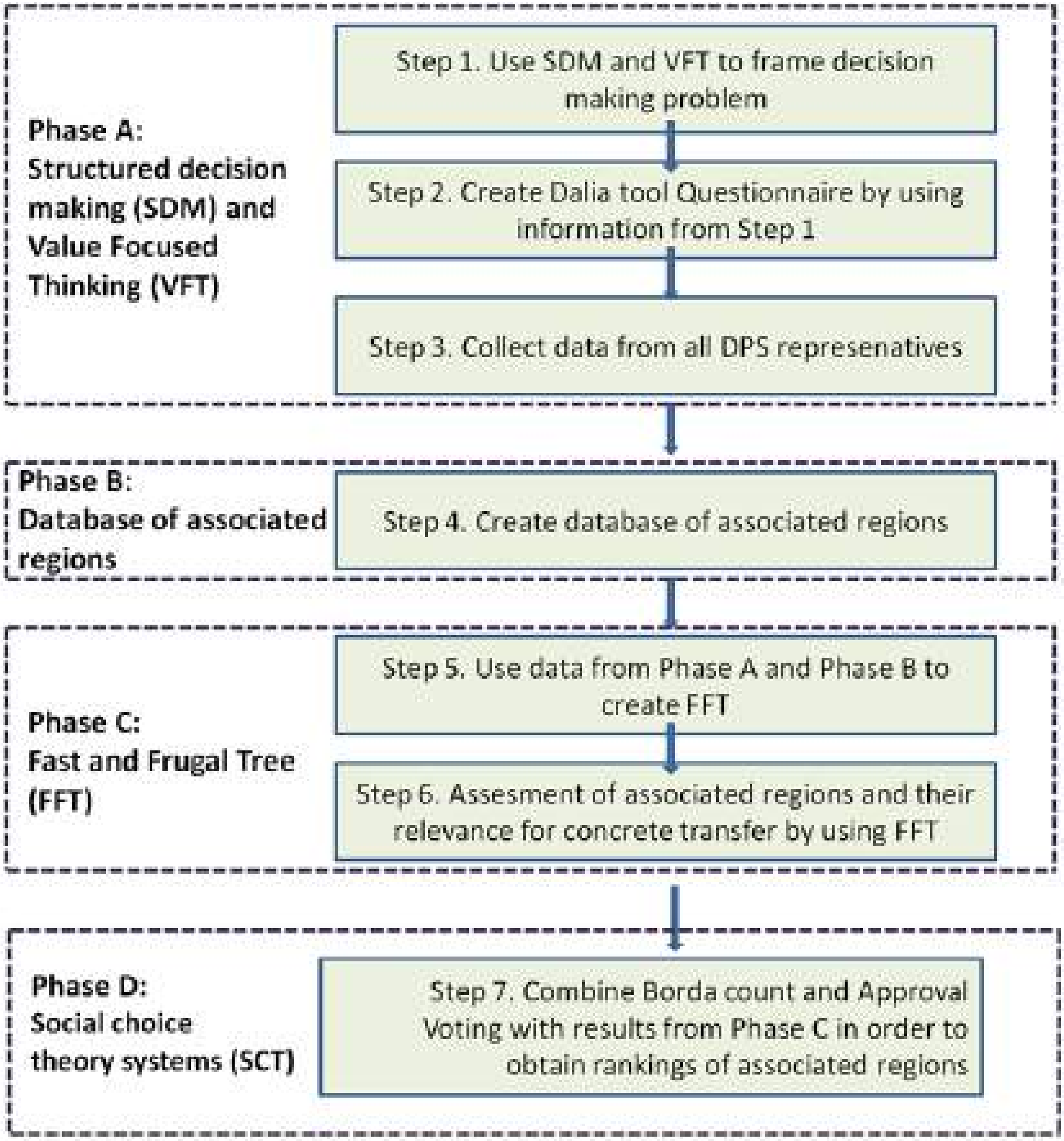

Approach used to create the DALIA tool

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The foundation of the DALIA tool lies in developing a well-crafted, detailed questionnaire to gather comprehensive information from representatives of the demonstration pilot sites (DPS). While creating such a questionnaire might appear straightforward, it is often more complex. Experts in decision-making emphasize the importance of identifying all relevant criteria for a decision-making problem (here criteria for comparisons of associated regions). However, they rarely provide clear guidance on how to do this or how to effectively use these criteria to guide the decision-maker’s thinking.

For example, decision-making theory shows that experts typically identify only about half of the relevant criteria (or objectives). More importantly, the criteria that are overlooked are not trivial but are often as significant as those initially recognized. This issue persists even when one feels familiar with the problem, whether in professional or personal decision-making.

A similar challenge arises when generating decision alternatives—in this case, when DPS representatives are asked to propose specific locations or associated regions for replication, along with the types of activities that can be replicated. Given these complexities, it is crucial to invest significant effort into specifying the criteria and alternatives.

To ensure a robust, scientifically sound approach, we conducted a literature review and identified two key theories to guide the development of our questionnaires: Structured Decision Making (subsection 1.1) and Value-Focused Thinking (subsection 1.2).

Moreover, while it is essential to list all relevant criteria and alternatives (here specific locations or associated regions for replication, along with the types of activities that can be replicated), it is not always feasible to gather comprehensive, reliable, and precise data for a detailed multi-criteria decision analysis. This limitation can hinder a meaningful evaluation of all eligible associated regions. Therefore, it was necessary to identify a suitable methodology that could facilitate the analysis based on a few key pieces of information or criteria.

Through a literature review, we discovered a highly effective tools known as the Fast and Frugal Tree (FFT) and Social Choice Theory Systems (SCT) which can yield even more accurate results than many complex models. These methods has been adopted, and its basic principles are outlined in subsection 1.3 (FFT) and 1.4 (SCT).

1.1. Structured Decision Making (SDM)-theory

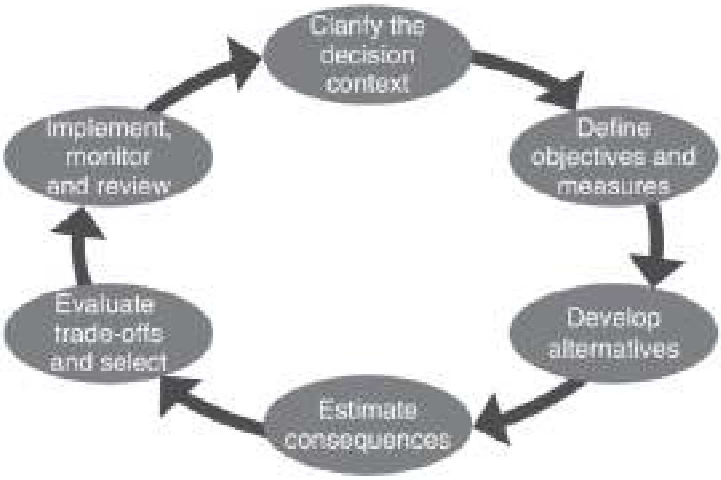
Structured Decision Making (SDM), is a distinctly pragmatic label given to ways of helping individuals and groups think through tough multidimensional choices characterized by uncertain science, diverse stakeholders, and difficult trade-offs in the messy process of making environmental-management decisions. Below are described basics of SDM and this is taken from Gregory et al. (2012).

SDM is defined as the collaborative and facilitated application of multiple objective decision making and group deliberation methods to environmental management and public policy problems. It combines analytical methods drawn from decision analysis and applied ecology with insights into human judgement and behaviour from cognitive psychology, group dynamics, and negotiation theory and practice. The primary purpose of an SDM process is to aid and inform decision makers, rather than to prescribe a preferred solution. In more everyday terms, we think of SDM as an organized, inclusive, and transparent approach to understanding complex problems and generating and evaluating creative alternatives. It's founded on the idea that good decisions are based on an in-depth understanding of both values (what's important) and consequences (what's likely to happen if an alternative is implemented) (Gregory et al., 2012).

Although there are different types of environmental management decisions and different deliberation contexts, using an SDM approach usually requires that each of the following questions is addressed:

1. What is the context for (scope and boundaries of) the decision?
2. What objectives and performance measures will be used to identify and evaluate the alternatives?
3. What are the alternative actions or strategies under consideration?
4. What are the expected consequences of these actions or strategies?
5. What are the important uncertainties and how do they affect management choices?
6. What are the key trade-offs among consequences?
7. How can the decision be implemented in a way that promotes learning over time and provides opportunities to revise management actions based on what is learned?

There are six core steps in SDM that can be usefully applied to nearly any environmental management decision, as shown in the figure below.



Steps in SDM (Gregory et al., 2012)

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Clarify the decision context

This step involves defining what question or problem is being addressed and establishing the scope and bounds for the management decisions. At this early stage, it is important to answer three initial questions:

- What is the decision (or series of decisions) to be made, by whom and when?
- What is the range of alternatives and objectives that can be considered? – not the details at this stage, just the general range and bounds: what's in and what's out.
- What kind of decision is it and how could it usefully be structured? What kind of analytical tools will be needed? What level and kind of consultation is appropriate?

Define objectives and performance measures

Objectives concisely define 'what matters' about the decision; performance measures are specific metrics for assessing and reporting how well an alternative performs with respect to an objective. Together, objectives and performance measures do two critical things: they drive the search for creative alternatives, and they form a consistent and transparent framework for comparing them. They define key concerns related to ecological, social, cultural, economic, or health and safety considerations, to the extent that these might be affected by the alternatives under consideration. They include important but hard-to-quantify values and outcomes as well as those more easily quantifiable.

Objectives and their corresponding performance measures must be carefully defined and accepted by key stakeholders as the basis for evaluating management alternatives. It's understood that different parties will attach different importance to different objectives, but weighting is not addressed at this stage; it will only be addressed if and when it is deemed necessary and useful as part of a later trade-off analysis. The goal of this initial stage is for participants to agree on what things matter and what needs to be assessed in order to effectively compare alternatives.

Develop alternatives

In some decision contexts, identifying alternatives is a passive affair – the alternatives are discrete things that are 'out there' waiting to be picked from a shelf. In many environmental management contexts, however, things are not so straightforward. Alternatives are usually complex sets of actions that need to be created rather than discovered. This act of creation is what SDM is all about – the development of creative alternatives that are responsive to the defined objectives. In contrast to economic or scientific approaches that focus primarily on valuation or risk, SDM focuses on identifying, comparing and iteratively refining alternatives. Alternatives should reflect substantially different approaches to a problem, based on different priorities across objectives, and should present decision-makers with real choices. In most environmental management contexts, it is important to search for alternatives that are robust to key uncertainties or that are likely to reduce them over time.

Estimate consequences

At this step, the consequences of the alternatives on the performance measures are estimated. This is a technical task, undertaken by 'experts'. Who's an expert depends on the nature of the task, but for any given decision it may include a combination of scientists (which we define broadly here to include natural and social scientists, economists and engineers) and local or traditional knowledge holders. The presence of uncertainty complicates the assessment of consequences, as does the presence of multiple legitimate forms of expertise. Groups involved in an SDM process must be willing to learn, to explore competing hypotheses, and to build a common understanding of what constitutes the best available information for assessing consequences. An honest and accurate representation of uncertainty based on a diversity of expertise will be essential. Consistent with the project goals, timeline and resources, attempts to reduce uncertainty may include collecting additional information, developing predictive modelling tools, or eliciting judgments about the range of potential outcomes from experts. Particular emphasis is placed on building an understanding of uncertainty as it affects the evaluation of alternatives. (Are some alternatives more uncertain or less well understood than others? If so, how might these sources of uncertainty be addressed? Are management actions sufficiently flexible to incorporate what is learned over time?)

A useful tool for summarizing consequences is a 'consequence table'. Variously termed a decision table, objectives by alternatives matrix, or facts table, this deceptively simple tool presents the consequences of policy or management options in a matrix with objectives and performance measures on one axis and the alternatives on the other. The level of rigor involved in estimating consequences can vary considerably depending on the nature of the decision. Some major decision processes may require months or even years of supporting analysis; others may require nothing more sophisticated than a one-to-five point scoring system sketched on a flipchart. In the context of environmental management problems, expert judgement will almost certainly play an important role.

Evaluate trade-offs and select

The goal of this fifth step is to choose an alternative (or set of alternatives) that achieves an acceptable balance across multiple objectives. Although an SDM process often delivers win–wins and synergies, most decisions will nevertheless involve trade-offs. Choosing a preferred alternative will involve value-based judgements about which reasonable people may disagree. SDM promotes exposing and facilitating an open dialogue about these trade-offs. Methods for making choices should allow participants to state their preferences for different alternatives based on credible technical information about the estimated consequences. There are a range of structured methods for this, some quantitative and some less so. Where the potential outcomes of choices are significant and controversial, formal multi-attribute methods can be used to bring clarity, consistency, and transparency to decision making. However, for most environmental management choices, decision-makers will retain the discretion and responsibility for making difficult choices; although quantitative trade-off methods can be helpful aids, they should not serve as formulas to prescribe an answer. Further, for a large proportion of environmental management decisions, thoughtful structuring of the problem (in terms of the fundamental objectives and alternatives), sound estimates of consequences and associated uncertainties, and structured deliberations about key trade-offs will result in wise, well-informed choices without explicit weighting or formal quantitative trade-off analysis. And because SDM clarifies areas of agreement and disagreement among stakeholders and the reasons for those disagreements, the results of an SDM process are useful to decision-makers whether a consensus is reached or not.

Implement, monitor, and learn

A structured decision process should promote learning and build management capacity to make better decisions in the future. This learning may be related to technical understanding (for example, reducing uncertainty in the estimation of consequences), human resources (for example, training local community members in monitoring methods) or institutional capacity (for example, building trust and partnerships and/or developing systems for tracking and storing data). Making decisions about things we care about can be hard at the best of times, and it's even more difficult when we're very uncertain about the outcomes. In such cases, an emphasis on learning over time, accompanied by a formal commitment to review the decision when new information is available, may be the key to reaching agreement on a controversial management strategy.

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1.2. Value Focused Thinking (VFT)

Below are described basics of VFT and this is taken from Keeney (1996). Values are fundamental to everything we do; and thus, values should be the driving force behind our decision making. They should be the basis for the time and effort we spend thinking about decisions. But this is not the way it is.

Instead, decision making usually focuses on the choice among alternatives. Decision problems are thrust upon us by the actions of others: competitors, customers, goverments, and stakeholders; or by circumstances: recessions and natural disasters. Faced with a decision problem, the so-called solving begins. Typically, the decision maker concentrates first on alternatives and only afterwards addresses the objectives or criteria to evaluate the alternatives. This is a standard problem-solving approach called alternative-focused thinking.

Focusing on alternatives is a limited way of thinking through decision situations. It is reactive, not proactive. This standard mode of thinking is backwards, because it puts identifying alternatives before articulating values. It is values that are fundamentally important in any decision situation. Alternatives are relevant only because they are means to achieve our values. Thus, our thinking should focus first on values and later on alternatives that might achieve them. Naturally there should be iteration between articulating values and creating alternatives, but the principle is 'values first'. Keeney (1992) called this way of thinking as Value Focused Thinking (VFT).

The purpose and thought processes of VFT are different from those of alternative-focused thinking. Alternative-focused thinking is designed to solve decision problems. VFT is designed to identify desirable decision opportunities and create alternatives. Therefore, the value-focused paradigm for addressing decisions is different from the standard alternative-focused paradigm in three important ways. First, significant effort is allocated to make values explicit. Logical and systematic concepts are used to qualitatively identify and structure the values appropriate to a decision situation. Second, this articulation of values in decision situations comes before other activities. Third, the articulated values are explicitly used to identify decision opportunities and to create alternatives.

Procedures of value-focused thinking

Almost all experts on decision making say that it is crucial to list all objectives. But they are not specific about how to do this or how to use the objectives to guide the decision maker (DM) thinking. VFT includes numerous procedures to assist DM. First, several techniques help compile an initial list of objectives. Second, these objectives are categorized as means or ends objectives and logically structured. Third, several procedures assist DM in using the objectives to create alternatives. Fourth, the objectives are examined to identify worthwhile decision opportunities.

Identifying objectives. The most obvious way to identify objectives is to engage in a discussion of the decision situation. The process requires significant creativity and hard thinking. You begin by asking the DM, "What would you like to achieve in this situation?" The responses provide a list of potential objectives and a basis for further probing.

There are several techniques that stimulate the identification of possible objectives. These techniques provide redundant guidance for identifying objectives, but redundancy is not a shortcoming. It is much easier to recognize redundant objectives when they are explicitly listed than it is to identify missing objectives. When asking an individual to express objectives, make it clear that what is needed is a list of objectives without ranking or priorities.

Creating alternatives. The range of alternatives people identify for a given decision situation is often unnecessarily narrow. There are several reasons for this. There is a tendency in problem solving to move away from the ill-defined to the well-defined, from constraint-free thinking to constrained thinking. There is a need to feel, and perhaps even measure, progress towards reaching a 'solution' to a decision problem. To get that feeling of progress, one often quickly identifies some viable alternatives and proceeds to evaluate them, without making the effort to broaden the search for alternatives.

The first alternatives that come to mind in a given situation are the obvious ones, those that have been used before in similar situations and those that are readily available. Once a few alternatives - or perhaps only one, such as the status quo - are on the table, they serve to anchor thinking about others. Assumptions implicit in the identified alternatives are accepted, and the generation of new alternatives, if it occurs at all, tends to be limited to a tweaking of the alternatives already identified. Truly different alternatives remain hidden in another part of the mind, unreachable by mere tweaking. Deep and persistent thinking is required to jar them into the consciousness. Focusing on the values that should be guiding the decision situation removes the anchor on narrowly defined alternatives and makes the search for new alternatives a creative and productive exercise.

Numerous guidelines facilitate the search for alternatives, or more precisely, the search for good alternatives. The principle is that alternatives should be created that best achieve the values specified for the decision situation. Both the qualitative objectives and the quantitative statements of values (e.g., priorities) should be systematically probed to initiate creative thinking. Ideally, DM creates the best possible alternative using the least amount of time, effort, and resources. But realistically, in complex decision situations, the practical aim in creating alternatives is to generate a set of very promising ones.

The objectives in the fundamental objectives hierarchy list all the aspects of consequences that are important in a decision situation. Hence, thinking about how to better achieve these objectives can suggest alternatives. To begin, DM should take one objective at a time and think of alternatives that might be very desirable if this were the only objective. Consider every objective, regardless of its level in the hierarchy. This exercise is likely to generate many alternatives (see Jungermann, yon Elardt and Hausmann, 1983), most of which evaluate rather poorly on some objectives other than the one for which they were invented. If this is not the case, DM has not been very creative in generating the alternatives. This process should provide a broad range of potential alternatives.

The next step is to consider objectives two at a time and try to generate alternatives that would be good for both. These alternatives are likely to be refinements or combinations of those created using single objectives. Then DM should take three objectives at a time, and so on, until all objectives are considered together.

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1.3. Fast and Frugal Heuristics

Humans and animals make inferences about their world with limited time, knowledge, and computational power. In contrast, many models of rational inference view the mind as if it were a supernatural being possessing demonic powers of reason, boundless knowledge, and all of eternity with which to make decisions. Such visions of rationality are often at odds with reality.

The term "**heuristic**" is of Greek origin, meaning "**serving to find out or discover**". After 1970, a second meaning of "**heuristics**" emerged in the fields of psychology and decision-making research: ***limited decision-making methods that people often misapply in situations where logic and probability theory should be applied instead*** (e.g., Tversky & Kahneman 1974). Gerd Gigernzer uses the term in the same positive sense as the earlier theorists, emphasizing their beneficial role in guiding search.

It may be more important to decide **quickly** than completely **accuratel**y. Results reported that **simple heuristics** do not always **make such tradeoffs.** When compared with some standard benchmark strategies on a range of decision tasks, **fast and frugal heuristics can be faster, more frugal, and more accurate at the same time**.

Heuristics are simple:

- Computations do not involve making tradeoffs between good and bad features. Just one, or very few, observable features are used.
- The heuristic also ties into the 'less-is-more effect', where having less information or recognition can sometimes lead to more accurate decisions, as excessive information can lead to overthinking or the dilution of strong cues by weaker ones.

Classes of heuristics

- **Ignorance-based decision making**

The simplest kind of choice – numerically, at least – is to select one option from two possibilities, according to some criterion by which the two can be compared. Many of the heuristics fall into this category, and they can be further arranged in terms of the kinds and amount of information they use to make a choice. In the most limited case, if the only information available is whether or not each possibility has ever been encountered before, then the decision maker can do little better than to rely on his or her own partial ignorance, choosing recognized options over unrecognized ones. This kind of "ignorance-based reasoning" is embodied in the recognition heuristic: when choosing between two objects (according to some criterion), if one is recognized and the other is not, then select the former.

In other words, the recognition heuristic is a decision-making process in which people infer the probability of an event or the value of an object based on whether they recognize it or not. **It's a form of cognitive shortcut that assumes if one recognizes something, it must have higher value or be more likely to be relevant than something one does not recognize.**

The recognition heuristic is a decision-making process in which people infer the probability of an event or the value of an object based on whether they recognize it or not.

Example 1. Which city is larger? Because we hear about large cities more often than small ones, using recognition to decide which of two cities is larger will often yield the correct answer (in those cases where one city is recognized, and the other is not). It's a form of cognitive shortcut that assumes if one recognizes something, it must have a higher value or be more likely to be relevant than something one does not recognize.

Example 2: Selecting companies for investment? When deciding which companies to invest in from among those traded on a particular stock market, the recognition heuristic would lead investors to choose just those that they have heard of before. Such a choice can be profitable assuming that more-often-recognized companies will typically have some of the better-performing stocks in the market – a testable, but not obvious, assumption.

Example 3: Who will win in tennis match at Wimbledon (2005) match? The outcomes of matches at the 2005 Wimbledon Gentlemen's tennis competition were predicted by mere player name recognition. In a field study, amateur tennis players (*n* = 79) and laypeople (*n* = 105) indicated players' names they recognized, and predicted match outcomes. Predictions based on recognition rankings aggregated across all participants correctly predicted 70% of all matches. These recognition predictions were equal to or better than predictions based on the official ATP rankings and the seedings of Wimbledon experts. The study shows that simple heuristics that rely on a few valid cues can lead to highly accurate forecasts.

- **One-reason decision making**

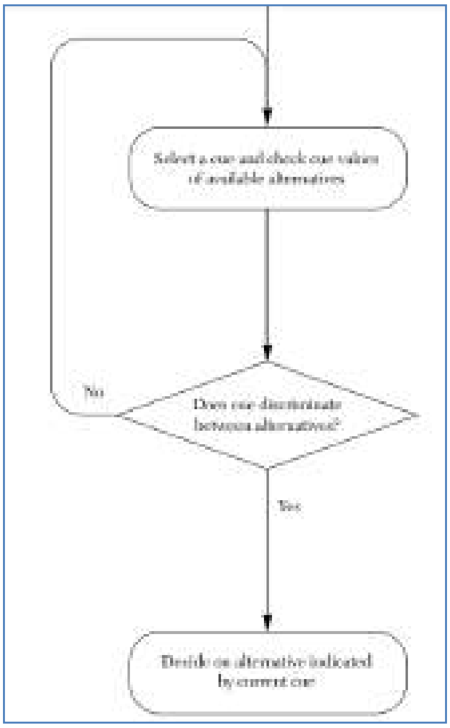
When multiple cues are available for guiding decisions, how can a fast and frugal reasoner proceed? The most frugal approach is to use a stopping rule that terminates the search for information as soon as enough has been gathered to make a decision. In particular, one can rely on one-reason decision making: *Stop looking for cues as soon as one is found that differentiates between the two options being considered*. This allows the decision maker to follow a simple loop, as shown below:

1. Select a cue dimension and look for the corresponding cue values for each option;

2. Compare the two options on their values for that cue dimension;

3. If they differ (e.g., if one value is larger or if there is positive information for one option but not for the other), then stop and choose the option with the cue value indicating the greater value on the choice criterion;

4. If they do not differ, then return to the beginning of this loop (step 1) to look for another cue dimension.



In more simple words, one-reason decision making is a decision-making strategy in which individuals base their choice on a single, highly relevant cue or reason, ignoring other potentially relevant information.

This approach is often used in situations where quick decisions are needed or when the decision-maker has limited cognitive resources or information. The decision is made based on one dominant factor or cue, which simplifies the decision-making process. By focusing on a single reason, decisions can be made quickly without the need for extensive

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deliberation or analysis. One-reason decision making can be effective in certain contexts, especially when the chosen cue is highly predictive of the best outcome. However, it can also lead to suboptimal decisions if important information is ignored or if the chosen cue is not as reliable as assumed.

Examples. Common examples include choosing a restaurant based on proximity, selecting a product based on price, or making a hiring decision based on a candidate's experience.

- **Elimination heuristics for multiple-option choices**

Often we must choose between several alternatives. In situations where each available cue dimension has fewer values than the number of available alternatives, one-reason decision making will usually not suffice, because a single cue will be unable to distinguish between all the alternatives. For instance, knowing whether or not each of 15 cities has a river is not enough information to decide which city is most habitable. But this does not doom the fast and frugal reasoner to a long process of cue search and combination in these situations. Again, a simple stopping rule can work to limit information search: Only seek cues (in an order specified by the search rule) until enough is known to make a decision. But now a different type of decision rule is needed instead of relying on one reason. One way of selecting a single option from among multiple alternatives is to follow the simple principle of elimination: Successive cues are used to eliminate more and more alternatives and thereby reducing the set of remaining options, until a single option can be decided upon.

In other words, elimination heuristics for multiple-option choices is a decision-making strategy in which options are sequentially eliminated based on whether they meet certain criteria or thresholds. This process continues until only one option remains, which is then selected. This method is particularly useful when dealing with a large number of options and when decision-makers need to simplify the choice process. By using elimination heuristics, the decision-maker systematically reduces the number of options, making the choice process more manageable and efficient.

Key features of elimination heuristics include:

- *Sequential Elimination*: Options are evaluated one at a time against specific criteria. If an option does not meet the criterion, it is eliminated from consideration.
- *Criteria-Based:* The decision-maker establishes a set of criteria or thresholds that are used to judge the options. These criteria are typically applied in a specific order of importance.
- *Simplification:* By focusing on one criterion at a time, the decision-making process is simplified, making it easier to handle large sets of options.
- *Efficiency*: This heuristic reduces the cognitive load by allowing the decision-maker to discard options early in the process, thus narrowing down the choices more efficiently.

Examples: A common example is a hiring process where candidates are eliminated based on failing to meet minimum qualifications, lack of specific skills, or insufficient experience until only the best candidates remain.

- **Satisficing heuristics**

All of the heuristics that we have mentioned so far for choosing one option from more than one operate with the assumption that all the possible options are presently available to the decision maker. But a different strategy is called for when the alternatives themselves (as opposed to cue values) take time to find, appearing sequentially over an extended period or spatial region. In this type of choice task, a fast and frugal reasoner need not (only) limit the information search, but (also) must have a stopping rule for ending the search for alternatives themselves.

More simply, a satisficing heuristic is a decision-making strategy in which the decision-maker selects the first option that meets a predefined minimum set of criteria, rather than seeking the optimal or best possible option. The term "satisficing" is a blend of "satisfy" and "suffice," reflecting the goal of finding a solution that is good enough, rather than perfect. Key features of satisficing heuristics include:

Minimum Criteria: The decision-maker establishes a set of minimum acceptable criteria that an option must meet to be considered satisfactory.

Sequential Search: Options are evaluated one at a time in the order they are encountered.

First Acceptable Option: The search stops as soon as an option meeting the minimum criteria is found.

Efficiency: This heuristic is efficient in terms of time and cognitive resources, as it avoids the exhaustive search for the best possible option.

Practicality: Satisficing is practical in situations where the cost of searching for the optimal solution is high or when a quick decision is needed.

Main drawbacks are that the first acceptable option may not be the best available, leading to potentially suboptimal outcomes and that by not evaluating all options, there may be missed opportunities for better solutions.

Example 1: Individuals searching for a partner. One instance of this type of problem is the challenge that faces individuals searching for a mate from a stream of potential candidates met at different points in time. There would be no optimal way of deciding when to stop looking for prospective marriage partners and settle down with a particular one. Satisfying will lead an individual to marry the first potential mate encountered who is over a desired level.

Example 2: Deciding where to eat. For example, when deciding where to eat, a person using the satisfying heuristic might choose the first restaurant they find that meets their minimum criteria for price, type of food, and distance, rather than searching for the absolute best restaurant available.

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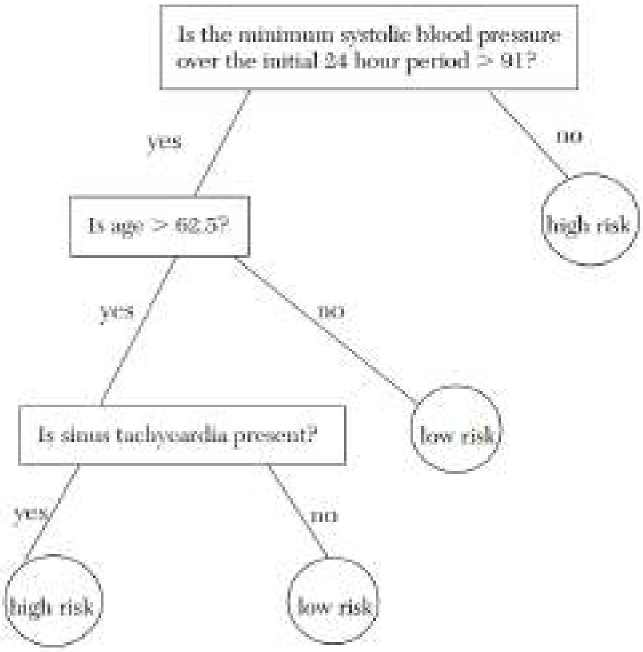
Fast and Frugal Tree (FFT)

In this section, we define a family of simple heuristics, called fast and frugal trees (FFT). We will try to illustrate idea behind FFT by using an example taken from Todd and Gigerenzer (2000):
"A man is rushed to a hospital in the throes of a heart attack. The doctor needs to decide whether the victim should be treated as a low risk or a high risk patient. He is at high risk if his life is truly threatened, andthreatened and should receive the most expensive and detailed care. Although this decision can save or cost a life, the doctor must decide using only the available cues, each of which is, at best, merely an uncertain predictor of the patient's risk level.

Common sense dictates that the best way to make the decision is to look at the results of each of the many measurements that are taken when a heart attack patient is admitted, rank them according to their importance, and combine them somehow into a final conclusion, preferably using some fancy statistical software package. In contrast, consider the simple decision tree in the figure below, which was designed by Breiman et al. (1993) to classify heart attack patients according to risk using only a maximum of three variables.



A simple decision tree for classifying incoming heart attack patients into high risk and low risk patients (adapted from Breiman et al. 1993)

If a patient has had a systolic blood pressure of less than 91, he is immediately classified as high risk – no further information is needed. If not, then the decision is left to the second cue, age. If the patient is under 62.5 years old, he is classified as low risk; if he is older, then one more cue (sinus tachycardia) is needed to classify him as high or low risk. Thus, the tree requires the doctor to answer a maximum of three yes/no questions to reach a decision rather than measuring and considering all of the several usual predictors, letting her proceed to life-saving treatment all the sooner.

This decision strategy is simple in several respects.

First, it ignores the great majority of possible measured predictors.

Second, it ignores quantitative information by using only <u>yes/no answers</u> to the three questions. For instance, it does not care how much older or younger the patient is than the 62.5-year cut-off.

Third, the strategy is a step-by-step process; it may end after the first question and does not combine (e.g., weight and add) the values of the three predictors.

Asking a maximum of three yes/no questions is a fast and frugal strategy for making a decision. It is fast because it does not involve much computation, and it is frugal because it only searches for some of the available information.

Its simplicity raises the suspicion that it might be highly inaccurate, compared to standard statistical classification methods that process and combine all available predictors. Yet it is actually more accurate in classifying heart attack patients according to risk status than are some rather complex statistical classification methods (Breiman et al. 1993). The more general form of this counterintuitive finding – that fast and frugal decision making can be as accurate as strategies that use all available information and expensive computation (Todd and Gigerenzer, 2000).

Fast and frugal trees are "minimal" in the sense of using the fewest number of question nodes and still involving all available cues, one at a time. Fast and frugal trees specify a number of cognitive processes. They specify how information is searched for, how the search is stopped, and how a decision is made based on the obtained information. The labels "fast" and "frugal" have precise meanings: The frugality of a tree for a set of objects is the mean number of cues, across these objects, it uses for making a categorization. The speed of a tree, also for a set of objects, is the mean number of basic operations – arithmetic and logical – used for making a categorization. It is clear that, by these definitions, changing question nodes into exits makes a tree faster and more frugal (Martignon, et al., 2008).

Fast and frugal trees differ from many other categorization models in three respects: First, the trees are deterministic. The motivation for this is that under conditions of limited time, information, and computation, people might not attempt or be able to compute probabilities. There are, of course, arguments against deterministic models, such as the inherent variability of human behaviour or the presence of individual differences. On the other hand, one may worry about how reliably the parameters of probabilistic models can can be estimated or argue that deterministic models make stronger predictions and are easier to falsify. Secondly, fast and frugal trees can only qualitative predictions about response times. Finally, cues are not combined and are considered one at a time. Specifically, in the next section, we will show that fast and frugal trees implement a particular type of one-reason decision-making (Martignon, et al., 2008).

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1.4. Social choice theory systems (SCT)

Typically used SCT systems are usually recognized as preferential and non-preferential voting methods. All the methods exclusively use ordinal preference information contained in the preference table created by collecting ballots. When applying voting methods, a special preference schedule table is constructed with the size of the table being MxN, where M is the number of voters (decision makers) and N is the number of decision elements (e.g., set of criteria or set of alternatives). Therefore, each row in the table represents the ranking of the criteria/alternatives performed by one decision maker. For simplicity, a decision element to be voted on by the voters (decision makers) will be labeled as 'd.e.'

There are numerous voting methods that are considered to be preferential because they all use information directly from a so-called preference schedule, which can be defined in the following way: if j is the best d.e. for the i_{th} decision maker, then the rank number is $r_{ij} = 1$; if j is the second best d.e., then $r_{ij} = 2$, and so on; if d.e. j is the worst one, then $r_{ij} = N$. In this way, each row of the preference table is simply a permutation of the integers 1, 2,…, N. One preferential voting methods has been used in this research and will be described here in brief, Borda count. In addition, one non-preferential method, approval voting, does not use a preference schedule but deals with so-called approval lists. This will also be described below.

The Borda count

In the Borda count, each d.e. gets 1 point for each first place vote received, 2 points for each next-to-first-place vote, etc. The total score for d.e. j is given as

$$B_j = \sum_{i=1}^{M} r_{ij}$$

The d.e. j^* with the lowest B value

$$B_{j*} = \min_{1 \le j \le N} B_j$$

is selected as the winner, i.e., the social choice.

Approval voting

Approval voting does not use information from a preference schedule and is therefore considered as non-preferential. In this method, the voters can vote for as many d.e. as they wish. Each approved d.e. receives one vote and the d.e. with the most votes wins. Approval voting is considered simple for voters to understand and use. In general, the method is practical because adding or removing a decision element does not change the point totals of the other decision elements. If the decision element(s) drop out, it is enough to simply remove it (them) from the list, and if decision elements are added, the vote totals for the original decision elements remain the same.

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2.CREATING DALIA TOOL QUESTIONNAIRE BY USING STRUCTURED DECISION MAKING AND VALUE FOCUSED THINKING

Step 1. Clarify the decision context

This step involves defining what question or problem is being addressed and establishing the scope and bounds for the management decisions. At this step, it is important to answer two initial questions:

- *What is the decision to be made, by whom and when?*

To analyze and to assess associated regions and their relevance for concrete transfer. This will be done by project partners participating in Task 2.1 Analysis of Associated Regions (UNSFA, OVF, CCSS, CZU, PaW, KUEI, SZE, TGM WRI, BIOPOLUS, NIHWM, MBAG, BRCCI, ASE, F6S) by the end of June 2024).

It is important to note **that we are not making the final decision on where DPS will be replicated**. Our **goal is to find potentially suitable Associated Regions for replication of DPS**.

- *What is the range of alternatives and criteria that can be considered? – not the details at this stage, just the general range and bounds: what's in and what's out.*

Range of alternatives:
Alternatives in our specific case represent Associated Regions which will be analyzed for DPS replication. Associated Regions (alternatives) must be located in EU Member States or associated countries **other than those that are part of the DALIA project consortium**. It means that following 35 countries represent associated regions: Albania, Armenia, Austria, Belgium, Croatia, Republic of Cyprus, Denmark, Estonia, Finland, France, Greece, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovenia, Spain, Sweden, Albania, Armenia, Bosnia and Herzegovina, Faroe Islands, Georgia, Iceland, Israel, Moldova, Montenegro, North Macedonia, Norway, Tunisia, Türkiye, Ukraine, United Kingdom.

Countries analyzed for DPS replications (see Annex)

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Range of criteria that can be considered:

In the Dalia project proposal, it is stated that we will analyze associated regions based on **socio-economic, environmental, and water-related criteria**. However, these are just general recommendations and we have freedom to select any other relevant criteria.

Step 2. Define criteria (or objectives) and performance measures

Because the decision sciences define ‘objective’ in a specific way, we need to take a moment to clarify what it is we mean. The deceptively simple answer is that, in any resource planning or evaluation situation, **objectives/criteria are the things that matter**. Performance measures are specific metrics for assessing and reporting how well an alternative performs with respect to an objective (criterion). Together, criteria and performance measures do two critical things: they drive the search for creative alternatives, and they form a consistent and transparent framework for comparing them. They include important but hard-to-quantify values and outcomes as well as those more easily quantifiable. Criteria and their corresponding performance measures must be carefully defined and accepted by key stakeholders as the basis for evaluating management alternatives.

What are good criteria?

Although there are no ‘right’ criteria, there are – at minimum – some that are more useful than others. A good set of criteria focuses decision makers on what matters in terms of the outcome of the decision and helps to identify and evaluate alternatives. Here are five properties of a good set of criteria (objectives).

***Complete*.** This means that no essential criteria are missing. A good set of criteria will capture all of the things that matter in evaluating proposed alternatives (associated regions). In most cases, this will include the key environmental, social, economic, health, and cultural outcomes that may be affected by the decision.

***Concise*.** This means that nothing is unnecessary or ambiguous. Similar criteria are grouped together and there is no double accounting. The reality is that people can keep up to 6–10 criteria in their minds, but any further additions just muddy the waters. Thus, a good set of criteria should ensure that all the important consequences can be described with the fewest possible criteria and measures.

***Sensitive*.** This means that the objectives are influenced by the alternatives under consideration. If an objective shows the same level of achievement for all of the alternatives under consideration, then it is not useful in distinguishing among the alternatives. It’s just more mud in the water.

Understandable. The objectives should be stated in a way that they are immediately understandable to everyone and speak directly to the things that matter. Use commonly understood terms rather than scientific jargon. Avoid ambiguity but bear in mind that many objectives are only made understandable using sub-objectives and eventually specific performance measures. For example, ‘conserve biodiversity’ is clearly stated, but may be interpreted in dramatically different ways unless it is more clearly defined by lower level sub-objectives and specific performance measures that define how biodiversity is to be understood in this decision context. As a result, conserve biodiversity might have a sub-objective to ‘maximize the diversity of native plants’ as measured by a ‘species richness’ index.

Independent. It is good practice to check that the objectives are also independent – or more formally, ‘preferentially independent’. This means that they contribute independently to the overall performance of an alternative, and you don’t need to know what’s happening on one objective in order to know how important another objective is. If that sounds complicated, think of it in terms of green vegetables. Imagine you’re serving both beans and broccoli for dinner. How important is it to you that your daughter eats a lot of broccoli? Well, it depends on how many green beans she eats, because what you really care about is not that she eats broccoli, but rather that she eats some green vegetables, or even more fundamentally, that she gets appropriate nutrition. Thus you want an objective that speaks to this higher-level concern, and the trade-offs you're interested in when preparing or consuming meals are (likely) between nutrition and cost and perhaps time available for leisure activities (if we assume that a good meal takes longer to prepare), and not between consumption of broccoli and consumption of beans.

Only once the criteria have been defined one should think about measurability of the bottom ones – often requires defining attributes:

- Natural attribute measures directly the achievement of a criterion (e.g. rental cost when selecting an office location)
- Proxy attribute measures indirectly the achievement of a criterion (e.g. time for commuting as a proxy for distance between home and office)
- Constructed attribute measures directly the achievement of a criterion when there isn't a natural attribute (e.g. office comfort defined by a set of qualitative levels)

Instruction how to create criteria/objectives

To encourage original thinking, it's usually best to ask people to write down their own ideas independently before starting to refine them as a group. By initially freeing each participant to search his or her mind without being limited by (or anchoring on) others' thoughts, the final result will be a more comprehensive set of criteria/objectives that more accurately reflects everyone's concerns.

According to that please ask a few relevant/competent people from your institution to fill this questionnaire independently. After that, refine results together as a group.

Step 3. Develop alternatives

From an outcomes perspective, a good alternative is one that has a good chance of providing a meaningful solution to the problem at hand. In other words, it addresses the decision makers' fundamental criteria/objectives. From a process perspective, a good alternative is one that is amenable to analysis and helps decision makers and stakeholders to learn, and ultimately gain clarity about, what would be a good solution. Alternatives with a good chance of delivering these share several common properties. They are complete and directly comparable, value-focused, fully specified, internally coherent, and distinct.

Value-focused. A focus on values means that alternatives are explicitly designed to address the things that matter, as defined by the objectives and the performance measures. Of course, different alternatives will vary in terms of how well they address different objectives/criteria. Some value-focused alternatives will seek win–wins (gains on multiple objectives) or a balance across objectives; others will emphasize one objective more than others. There's no saying which is right. The key is that the alternative is designed with the fundamental objectives/criteria in mind.

Fully specified. Fully specified means that the alternatives are defined to a sufficient level of detail, using logically consistent assumptions. Ambiguity in the specification of alternatives is an important source of errors and inconsistencies in the subsequent estimation of consequences.

Instruction how to develop alternatives

With objectives/criteria, we were always asking why? With alternatives, we ask how? – how can the stated objectives best be achieved or fulfilled? A value focused way to generate alternatives works through the list of objectives and identifies alternatives that satisfy each concern.

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Finally, watch out for anchoring. One of the most common traps in decision making is to anchor on a single alternative (often the status quo) and tweak it. One way to minimize this bias is to develop a set of creative, value-focused bookend alternatives first, and then come back to develop a base case in detail.

Iteratively improve alternatives. The development of alternatives typically occurs iteratively, and new and better alternatives are the result of the learning gained from estimating their consequences. The process is iterative. It starts with a brainstorming session that leads to the generation of a first round of alternatives – perhaps a reference case, a couple of bookends, and a few more alternatives. These alternatives are then analyzed. In many cases, the results are brought back to a working group, which reviews the results and deletes clearly inferior alternatives, proposes refinements to the remaining alternatives or, based on what has been learned, identifies totally new ones.

Common pitfalls and traps. As in all the steps of decision making, people's ability to think clearly and creatively about alternatives is hampered by a host of psychological, cognitive, and traps. Here are some of the most common traps and pitfalls:

Anchoring and tweaking. Starting from the status quo, or the first proposed alternative, or what's going on in a neighbouring jurisdiction, and then making only minor incremental changes.

Avoiding trade-offs. Not presenting an alternative because it would be controversial, or glossing over difficult value-based choices, or trying to eliminate them too soon.

Quitting too soon. A variety of pressures cause participants in a decision to rush to a premature solution with a false sense of urgency – an imposed time constraint that isn't real, or a sequenced decision process where it's presumed the next steps are awaiting the results of this stage of the process.

To encourage original thinking, it's usually best to ask people to write down their own ideas independently before starting to refine them as a group. By initially freeing each participant to search his or her mind without being limited by (or anchoring on) others' thoughts, the final result will be a more comprehensive set of alternatives (associated regions).

Creating Alternatives with value-focused thinking:

- Specify the objectives to be achieved and then use them to guide the search for alternatives.
- It is useful to focus first on each objective one at a time and ask ourselves, what are some alternatives that might measure up well in terms of this objective?
- Then one considers sets of more than one objective and asks an analogous question.

2.1. Questions for DPS representatives

1. Short description of DPS emphasizing the part of the pilot that is planned to be replicated (keep in mind that the budget for replication is 100.000 euros).

2. What kind of data you needed to gather before you created, developed and installed your DPS? What kind of hydrological, climatic, environmental, socio-economic data?

3. Describe what goal can be achieved with replication of DPS? What will be the expected outcomes/expected changes and potential benefits of that replication? If possible, please try to list at least one benefit in each of the following categories:
   - ➔ socio-economic
   - ➔ environmental
   - ➔ water related

4. What criteria should be analyzed when deciding where to replicate your DPS (part of DPS with value about 100.000 euros)? Please try to list everything that is relevant? For instance, try to list at least one criterion for each of the following categories:
   - ➔ hydrological criteria (water quantity, type of river: lowland, mountain river, etc.):
   - ➔ climate criteria
   - ➔ soil criteria
   - ➔ geomorphologic criteria
   - ➔ vegetation criteria
   - ➔ water quality
   - ➔ socio-economic criteria
   - ➔ tourism: ways, posters
   - ➔ recreational
   - ➔ wildlife, etc.

5. How would you measure the previously listed criteria (define what type of attributes: natural, proxy or constructed)? For definition of attributes see description below in italic:

   Only once the criteria have been defined one should think about measurability of the bottom ones – often requires defining attributes:
   - o *Natural attribute measures directly the achievement of a criterion (e.g. rental costs when selecting an office location)*
   - o *Proxy attribute measures indirectly the achievement of a criterion (e.g. time for commuting as a proxy for distance between home and office)*
   - o *Constructed attribute measures directly the achievement of a criterion when there isn't a natural attribute (e.g. office comfort defined by a set of qualitative levels)*

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6. To your best knowledge, is it easy or complicated to obtain data for previously listed criteria and attributes for other associated regions?

7. What are the limitations where your DPS may be replicated? For example, for pilot-constructed wetland replication criteria are settlements with less than 5000 citizens, locations where exist empty lot of size more than 2 ha.

8. Please suggest associated regions or specific locations (minimum 5) where your pilot may be replicated (for each location, explain why you think it is suitable to be a replication location in more detail as possible; what are the conditions that make it perfect for your pilot; do you have data for that location and which one (for example climate, natural conditions, socio-economic data, etc.).

9. Now, use objectives/criteria from question 4 to guide the search for locations (associated regions). First, focus on each objective/criterion one at a time and ask yourselves, what are some locations that might measure up well in terms of this objective? Then one considers sets of more than one objective and asks an analogous question. For instance, ask yourself which locations can be good for replications according to the water quality criterion? Then, which locations can be good for replications according to the hydrological criterion? Etc.

10. For listed locations, try to provide estimation if it is possible to obtain data related to the previously listed criteria/objectives.

3. RESULTS OF QUESTIONNAIRES

3.1. General overview of Demonstartion Pilot Sites

The information in the General Overview section has been taken from "D1.1 Detailed Analysis of Demonstrators' Ecosystems".

3.1.1. DPS1

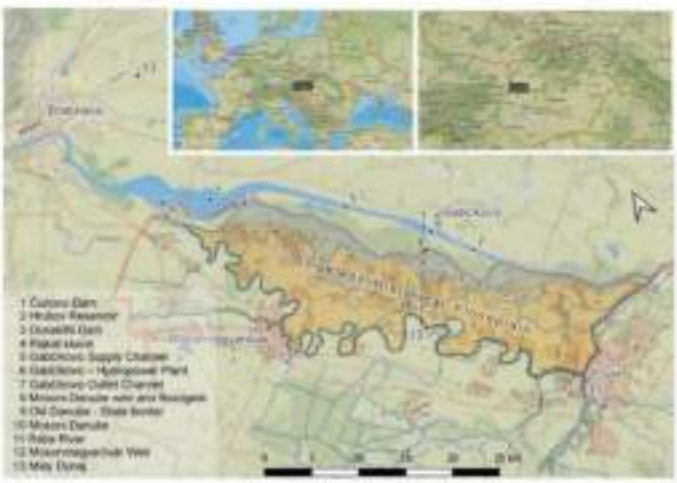
Location: Szigetköz, West-transdanubia, Hungary

Short form of the organization: SZE - Széchenyi István University is located halfway between the capital cities of Hungary, Austria and Slovakia, on the banks of the Mosoni Danube. The University offers unique education and research in the region, which serves engineering oriented production activities and contributes to the development of the North Transdanubian economy and its social and institutional infrastructure. A Water Resources Research Group has been established at the University. The main focus of the research is to respond to short and medium- term water resource issues and to prepare effective water management decisions.

General Overview

The Danube exits the swift channels of the Alps and the Carpathians near Bratislava, Slovakia. Beyond this point, its gradient and velocity decrease significantly. The river deposits sediment, creating countless islands in a tangled system of river branches, commonly called an inland delta (Dr Göcsei Imre, 1979). The Mosoni-Danube forms the southernmost branch of the Danube. The area between these two branches is called Szigetköz (Maly Žitný Ostrov). Szigetköz is Hungary's largest island with a land area of about 375 km². There is also a large island on the Slovakian side called Csallóköz (Žitný Ostrov).

In the 19th century, Hungarian river regulators created the main riverbed (Old Danube) in the middle of a tangled system of branches by means of large-scale river regulation to improve navigation conditions. Following the river regulation, continuous flood protection dikes were built on both banks of the Danube in the early 1900s, dividing the historic floodplain into active and historic (inactive) floodplain areas.



An overview map of the Szigetköz region

Several river branches fragment the active floodplain. The islands between the branches are mainly covered with floodplain forests (17% of the total area of Szigetköz) (Szabó, 2006). The historic floodplain of Szigetköz is a mosaic landscape, the most important part of which is agricultural land, typically arable land (55%). There are smaller amounts of meadows and pastures (10%). Thin strips of forest, canals, oxbow lakes, swamps, reeds and other water bodies and wetlands (10%) form the edges of the landscape. More than 20 settlements (8%) are located within the historic floodplain.

There is a slight difference between the climatic parameters of the north-western (Upper Szigetköz) and the southern (Lower Szigetköz) parts of the region; where the NW is moderately cool and the SE is moderately warm, with a dry climate. The average annual temperature is 9.7-10.0 °C. The annual rainfall is 550-600 mm. The average number of snow days in winter is about 30. The prevailing wind direction is north-westerly, with an average wind speed of 3 m/s.

The soils of the Szigetköz developed from alluvial material under the influence of climate, vegetation and groundwater conditions (Várallyay, 1992). The soil-forming rocks of the area are young, typically sandy-silty alluvial deposits of the Danube. They are characterised by a light mechanical composition and carbonate nature, with varying degrees of underlying gravel at different depths (several hundred metres). Meadow processes dominate in areas that are not flooded but where the water table is close. Chernozem soil formation processes predominate in areas where the water table is deep.
Most areas of the active floodplain and some parts of the historical floodplain have been protected as the Szigetköz **National Landscape Protection Area** since 1987 and are part of the **NATURA2000 network**.

3.1.2. DPS2

Reconnected floodplain of the Upper Danube, Germany

Location: Alluvial forest between Neuburg and Ingolstadt, District of Neuburg-Schrobenhausen, Bavaria, Germany

Short form of the organization: The Catholic University of Eichstätt-Ingolstadt (KUEI) is an independent, non-governmental, fully state-recognized university, founded in 1980 and supported by an ecclesiastical foundation under public law. The Aueninstitut Neuburg (AI) of the KUEI is a research centre closely associated with the Chair of Applied Physical Geography at the Faculty of Mathematics and Geography. It focuses on applied research in floodplain ecology and restoration, on the development and improvement of near-natural floodplain solutions, on ecological monitoring, assessment and valorization of floodplain dynamics and related ecosystem services.

General Overview

The pilot site DPS2 is situated between the barrage Bergheim and Ingolstadt on the left side of the Danube. The floodplain forest in DPS2 is a small, about 8 km long part of a 2,100 ha floodplain forest area along the Danube in Bavaria, which is one of the largest contiguous floodplain forest complexes in Germany (MARGRAF 2004).

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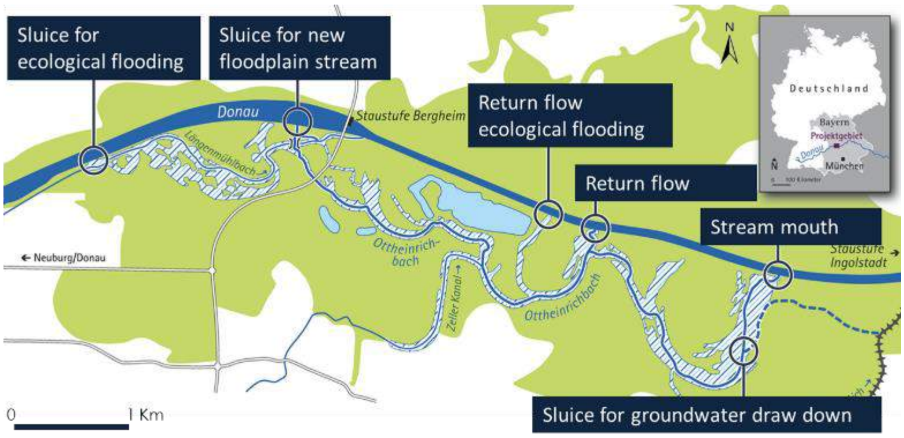
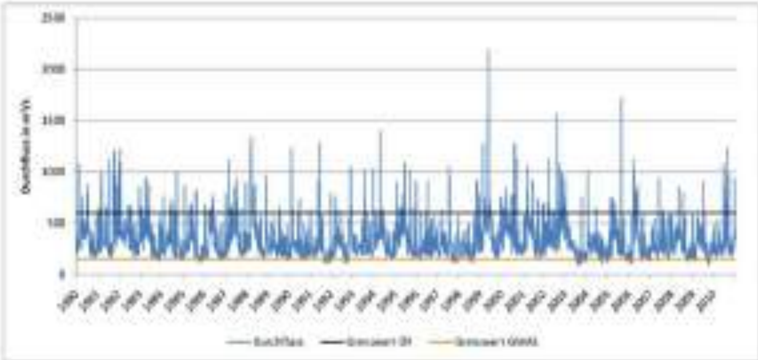


Study area of the DPS2 between the Bergheim barrage and Ingolstadt with labeling of selected important structures

The **Danube**, a 1st order water body (BAYWG Art. 2 2010), forms the border between the natural landscapes of the Alpine foothills and the German low mountain ranges and is not open to navigation. The discharge of the Danube is strongly influenced by the alpine tributaries Iller and Lech. In early summer, floods occur more frequently due to snowmelt in the Alps, and periods of low water can be expected in late fall and early winter. When the Danube carries a lot of water due to snowmelt, ecological flooding can occur in the project area (DPS2). The **Danube valley** is demarcated as a separate fluvio-glacial natural area (BAYSTMLU 1999), which also includes the Danube moss in the Ingolstadt basin bordering the study area to the south. The Danube floodplains can be assigned to the floodplain type "river floodplains of the foothills of the Alps, rich in precipitation, with summer floods, gravel/gravel-dominated" (KOENZEN 2005).

In addition to the Danube, there are **other important surface waters** in the study area. Among them are two smaller but still significant flowing waters: One is the **Längenmühlbach**, which rises at the northwestern edge of the Donaumoose and flows into the Danube below the Bergheim barrage. (It was used as a drainage ditch after the construction of the Bergheim barrage). The other one is the **Zeller Canal**, which has its origin in the Danube moss, after which it flows into the Danube before the dynamization. Since the opening of the bypass watercourse, it flows into the Ottheinrichbach. The water flow is periodic and strongly dependent on precipitation (drying up in summer). The largest oxbow (former river loop) in the project area is the "**Old Danube**". It is located north of Weichering and was largely disconnected from the Danube by a check valve before the dynamization project. Water could only flow into the Danube on one side in the direction of the flow of the Zellerkanal. Furthermore, there are numerous permanent or temporary **water-bearing ponds** and flood channel systems in the project area, which are flooded by surface water and/or filled by rising groundwater, especially during flood events (MARGRAF 2004). In addition, there are **several large lakes** in the study area (Albenschüttweiher, Großer and Kleiner Schlossweiher), which were formed anthropogenically by gravel mining. All three lakes are groundwater-fed.

It is also necessary to consider the **hydromorphological situation in the pilot area**, as it is important to deal with the soil properties so that the renaturation measures (e.g. stream course through the alluvial forest or ecological flooding) will work properly in the floodplain area. It is also important to consider backwater layers (aquiclude). It is especially helpful if there are thick gravel layers in the subsoil through which water can spread far into the floodplain forest. Soil properties and groundwater fluctuations were studied in more detail at the pilot site: The evaluation of the soil survey of the project area by FREYTAG-LORINGHOVEN (2000) shows: 87.9% are alluvial loams plus 0.1% alluvial loams with humic parts, 10.8% of the areas are occupied by gravels and 1.2% by sands. The water supply of the soils depends on the soil type, the distance between the groundwater courses as well as on the soil thickness. The gravel-dominated soils of the burns are the driest, while capillary rise is better in alluvial loam soils. According to FREYTAG-LORINGHOVEN (2000), well-watered soils (reservoir-fresh, ground-fresh, and ground-moist), measured by their water content, occupy the largest proportion of soils in the project area at 55.2%. 22.5% of soils have medium water supply, 19.1% are relatively dry (from very dry to moderately fresh), and only 3.3% are particularly moist and wet soils.



Flow rate Q in m3/s at the Ingolstadt barrage from 1980 to 2010 (daily mean values, data WWA-Ingolstadt). The two lines mark the limit values for the dynamization measures Ecological Flooding (ÖF) and Groundwater Lowering (GWAS).
Quelle: Cyffka, B. et al. (2016): Neue dynamische Prozesse im Auenwald.: page 29, figure 2-4

The project area also has an important **international status.** It is designated as a landscape conservation area and is also registered with the EU as an FFH and SPA area as part of the European biotope network NATURA 2000 (HERRMANN 2004). The water protection areas Weichering (district of Neuburg-Schrobenhausen) and Buschletten (city Ingolstadt) are located in the study area. The near-natural floodplain areas (approx. 90% of the project area) with forests, water bodies, reed beds, burns, etc. are classified as "Official Biotopes" (§ 30 BNATSCHG and Art 23 BAYNATSCHG).

3.1.3. DPS3

Location: Dyje subcatchment of the Danube River catchment, Czech Republic

Short form of the organizations: The T. G. Masaryk Water Research Institute (TGM WRI), a public research institution, was established as one of the first scientific institutes in the independent Czechoslovak Republic. In the field of hydrology, TGM WRI focuses on issues of quantification and protection of water resources (especially in response to a series of major floods and droughts), development and application of methods for measuring and monitoring parameters of water movement in watercourses and reservoirs, as well as issues of hydroecology and various aspects of water quality in general.

The Czech University of Life Sciences Prague is the third largest university in Prague. Backed by one hundred years of history, CZU combines cutting-edge technologies, advanced science and research in agriculture, forestry, environment, engineering, economics, management and business. CZU offers complete higher education, summer schools, lifelong learning courses and the University of the Third Age to more than 20,000 people. CZU cooperates with several private and public organizations and research institutions both locally and internationally. The university is a member of the EuroLeague for Life Sciences (ELLS), a prestigious network of universities. It is also one of the twenty-eight members of Agrinatura, a group of European universities and research institutions dedicated to sustainable agricultural development. In recent years, CZU has established the Center for Precision Agriculture, the Bioeconomy Platform of the Czech University and the Center for Water, Soil and Landscape.

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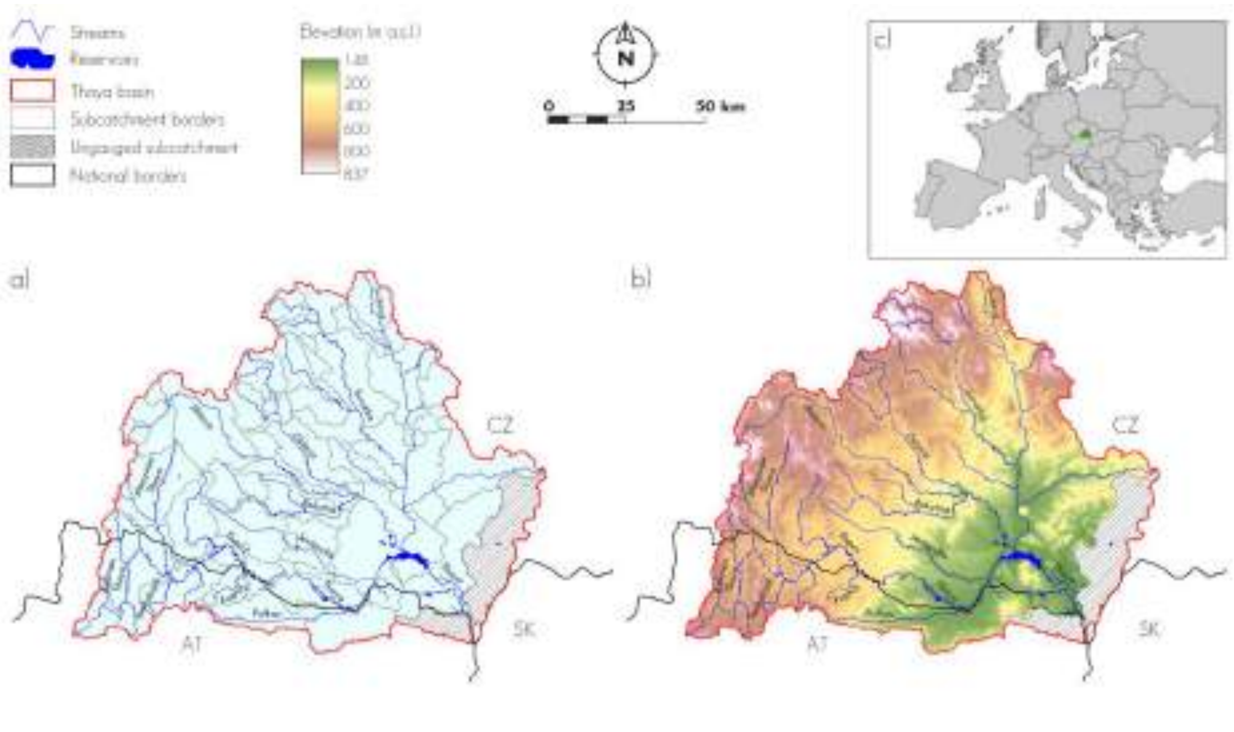
General Overview

The Demonstration Pilot Site 3 (DPS3) covers the entire catchment area of the Thaya River. The Thaya River Basin drains a total area of 13,419 km² and is located in the southern part of the Czech Republic (83%) and the northern part of Austria (17%). The Thaya River (in Czech language Thaya) is formed by the confluence of the Austrian (or also called German) and Moravian Thaya Rivers in Lower Austria and is the longest tributary of the Morava River (Danube basin). The sources of the two tributaries are both located in the highlands at altitudes of 676 m (AT) and 635 m (CZ). The main tributaries are located in the Moravian part of the basin and flow mainly in a NW-SE direction. The Jihlava flows through the city of the same name and the Svratka, together with the Svitava, drains Brno, the second largest city in the Czech Republic. The upper reaches of the river are formed on crystalline bedrock, while the lower parts consist of quaternary sediments. Soils follow a similar pattern, consisting mainly of cambisols in the highlands (58%) and fertile chernozems in the lower reaches (20%). The middle and lower course of the Thaya is characterised by anthropogenic modifications, including large reservoirs built for water supply or irrigation purposes.

The long-term annual (precipitation) of the higher parts of the Thaya catchment exceeds 650 mm and the annual (runoff) coefficient is between 0.2 and 0.3 with a mean annual runoff of 187 mm. However, the lowland region with lower annual precipitation combined with high evapotranspiration (ETo) results in a significantly reduced runoff coefficient (0.1-0.15) due to a mean annual runoff of almost 60 mm. The relatively limited water resources barely meet the water needs of households, industry, energy and agriculture. The water shortage is partly solved by water retention in 21 surface water reservoirs on the Thaya or its tributaries.

The characteristics of the lowlands, together with the mild and warm climate, make the agricultural landscape of the Thaya basin fertile. **Arable land covers 66% of the basin, while forests cover 28% (16% coniferous, 6% mixed and 6% deciduous)**. The coniferous forests faced an unprecedented bark beetle outbreak, forced by high Ta (temperature) and a severe drought period from 2015-2019. This outbreak caused a significant decline in coniferous forest stands, requiring a radical increase in sanitary logging, which by the end of 2020 represented about 30% of the total area of coniferous stands in the basin compared to 2012.



The Thaya river basin with 42 surveyed sub-basins and river/reservoir network; b) Digital elevation model of the basin; c) Position of the Thaya river basin within Europe

The Thaya River flows into the Morava River (which flows into the Danube) in the border triangle of the Czech Republic, Austria and Slovakia, in an area of extensive floodplain forests. The area is called the Lower Morava Biosphere Reserve (BR) (dolnimorava.org), which was proclaimed in 2003 as an extension of the former BR Pálava, originally proclaimed in 1986, covering an area of 349 km². It is located in South Moravia, about 35 km south of Brno, on the borders with Austria and Slovakia. The dominant landscape of BR is Pavlovské kopce - Pálava. It is formed by limestone cliffs and its steep slopes are covered with steppes, forests and meadows, as well as vineyards and fields.

The northeastern part of the BR is located in the flat floodplain of the Thaya River, which is intensively used economically, especially for agriculture, so that there are only remnants of the original floodplain meadows and forests. Arable land predominates in the southern and eastern parts of BR. However, in the south-eastern corner of the territory, in the triangle defined by Břeclav, Týnec and the confluence of the Morava and Dyje rivers, there is the **largest complex of hard floodplain and** in Central Europe (approximately 8,000 ha in total). The central part of the BR is located in a depression with ponds and a man-made landscape created in the 19th century, which is currently on the UNESCO World Heritage List. The pilot area is part of the RAMSAR Convention for the protection of wetlands. The Dolní Morava BR includes a large number of sites of national and international importance. These include, for example, the territory of the European Natura 2000 system, specially protected areas led by the Pálava Protected Landscape Area, the Lednice-Valtice Area, wetlands registered under the Ramsar Convention, two nature parks (Niva Thaya and Mikulčický Luh) or the protected area of the natural water accumulation of the Morava River Quarter and others. The Nature and Landscape Protection Act No. 114/1992 defines several categories of specially protected areas. These are: national parks (NP), protected landscape areas (PLA), national nature reserves (NPR), nature reserves (PR), national natural monuments (NPP) and natural monuments. In the Dolní Morava BR you will find all of them except the National Park.

3.1.4. DPS4

Location: Slovakia Upper Catchment of Vah River, Kysuce Region

Short form of the organization: Founded in August 1993, the NGO People and Water supports municipalities and regions in the development of integrated water protection programs. The NGO's activities are devoted to education, implementation of pilot projects, awareness-raising and support of legislative changes related to the use and protection of water resources, flood protection, water scarcity, and enhancement of biodiversity and negative consequences of climate change mitigation.

General Overview

The hydrology of the Danube River is significantly influenced by the management of rainwater in the landscape. The underestimation of the impact of human economic activity in the rural landscape on the water regime of the country has led to the decrease of water resources in headwater areas both in Slovakia and throughout the entire Danube basin. As a result, springs and small watercourses in Slovakia are drying up on a large scale, which has a significant impact on the reduction of river flows during long-term droughts. Our experience confirms that it is realistically possible to restore the supply of underground water sources and the yield of springs by simple and inexpensive measures applied in a knowledgeable and systematic way. Because of this, the Slovak pilot site of the DALIA research project is focused on measurement and demonstration, in order to prove that by strengthening the water retention capacity of damaged ecosystems we can improve the yield of surrounding water resources in spring areas. The results can be a significant contribution to the strategic planning and integrated management and use of watersheds, in Slovakia and elsewhere.

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The Slovakian part of the Danube basin, with an area of 46,961 km² (5.9% of the total area of the Danube basin), is characterized by spring water resources, which influence the hydrology of the Danube through natural factors. The various types of land use, including forestry, agriculture, and urbanization of the landscape, also greatly impact the hydrology of the region. The Slovakian headwaters are crossed by more than 65,000 km of small watercourses, which flow into larger rivers and streams that directly feed the Danube or contribute to the hydrology of watercourses on the Hungarian side. These watercourses form the backbone of the Danube's tributaries.

Approximately 1/3 of the territory of Slovakia is the watershed of the Váh River with an area of 15,782 km². Together with the Hron River (5,465 km²), these two rivers are the only two rivers in Slovakia that flow directly into the Danube. Other rivers flow into Hungary and influence the hydrology of the Hungarian lowland rivers before they reach the Danube. This means that what happens in the river basins of Slovakia is sensitively reflected in the rivers of Hungary and also directly in the Danube, even if only in a small percentage.

Long-term observations show that 34.3 billion m³ of rain and snow fall on Slovakia every year. From this precipitation, about 12 billion m³ of water will flow through river networks to the Danube.

From a hydrogeological point of view, the petrographic-lithological environment of the flysch sediments represents **variable hydrogeological conditions**. The accumulation and circulation of water is concentrated in weathered zones in contact with overlying debris, on gentle slopes and in partial depressions, and deeper in positions of more permeable sandstones. In general, the Paleogene sediments, represented by the flysch formation with a predominance of clays, represent a poorly permeable to impermeable environment.

The lithological nature of the units does not create particularly favorable conditions for significant accumulation and circulation of groundwater. A significant part of the territory of the Paleogene flysch zone is a typical example of an area where the underground zone plays a decisive role as the main hydrogeological collector. On the slopes of more morphologically fragmented areas, the underground zone acts only as a transit zone, because after the interruption of the precipitation subsidy, this collector is gradually drained by the natural gravitational outflow of groundwater. Thus, the influence of the geological structure on the groundwater circulation is strongly suppressed by the **geomorphological conditions**. The share of the deeper stratified water circulation in the total circulation is relatively small due to the higher permeability of the near-surface zone and the significant decrease of the average permeability of the rock massif with depth. Due to the dominance of fracture permeability, the influence of tectonic disturbance is significant. The near-surface loosening zone has a significantly higher permeability than the deeper parts of the massif. It shows a more or less regular decrease of the average permeability with depth.

Groundwater collectors in the flysch zone are formed by sandstones, characterized by fracture permeability, clays are in the form of a hydrogeological insulator. Vsetin layers building the territory in question, i.e. formation in the sandstone development represents a hydrogeological collector. Its drainage is associated with fractures, weathering zones and cracks of tectonic origin.

Geographical position and altitude have a significant influence on the **climatic conditions** of the area. The Kysúc region belongs to the moderately cold climatic zone (C1), humid sub-region, with cold winters. The natural conditions are manifested in a different annual and daily course of all climatic elements, which have distinct continental features. The winter is relatively long, the spring comes slowly, and the summer temperatures are low. Rainfall is usually short and intense. Most of the precipitation falls during the summer months. Winter is relatively dry. The evaluated area is characterized by a basin climate with a large inversion of temperatures, slightly dry to humid, subtype moderately warm.

Map of Slovakia, Váh River basin with Kysuca river tributary, location of pilot projects in Slovakia (Blue Alternative and Water Forest

In the Kysúce basin there is an economically used area with a forest cover of 51%. This area has been significantly damaged by flood disaster, which is reflected in the hydrological regime. The northwestern part of the Kysúce Basin consists of the Kysúce **Protected Landscape Area** with an area of 65,462 ha. There are 13 small protected areas with the status of "**nature reserve**" or SPA.

3.1.5. DPS5

Location: Begečka Jama, Serbia

Short form of the organization: The Faculty of Agriculture is a part of the University of Novi Sad, an institution of higher education and scientific research whose mission is to stimulate quality educational processes, development of scientific disciplines and dissemination of knowledge gained in the economy and society. The Faculty of Agriculture carries out its mission in three interrelated groups of activities: higher education, scientific research, and application of knowledge in the field of economy. Moreover, as a part of the comprehensive educational and scientific system, it is a driving force for social development and the initial force for the development of agriculture in Serbia and the Western Balkans.
General Overview

The area of the *Begečka Jama pilot site* is located in the province of Vojvodina in Serbia, on the left bank of the Danube, about 20 km west of the city of Novi Sad. It comprises the protected area (*Begečka Jama Nature Park*) and the surrounding drainage basin (Begeč-Gložan drainage system) (Figure 1).

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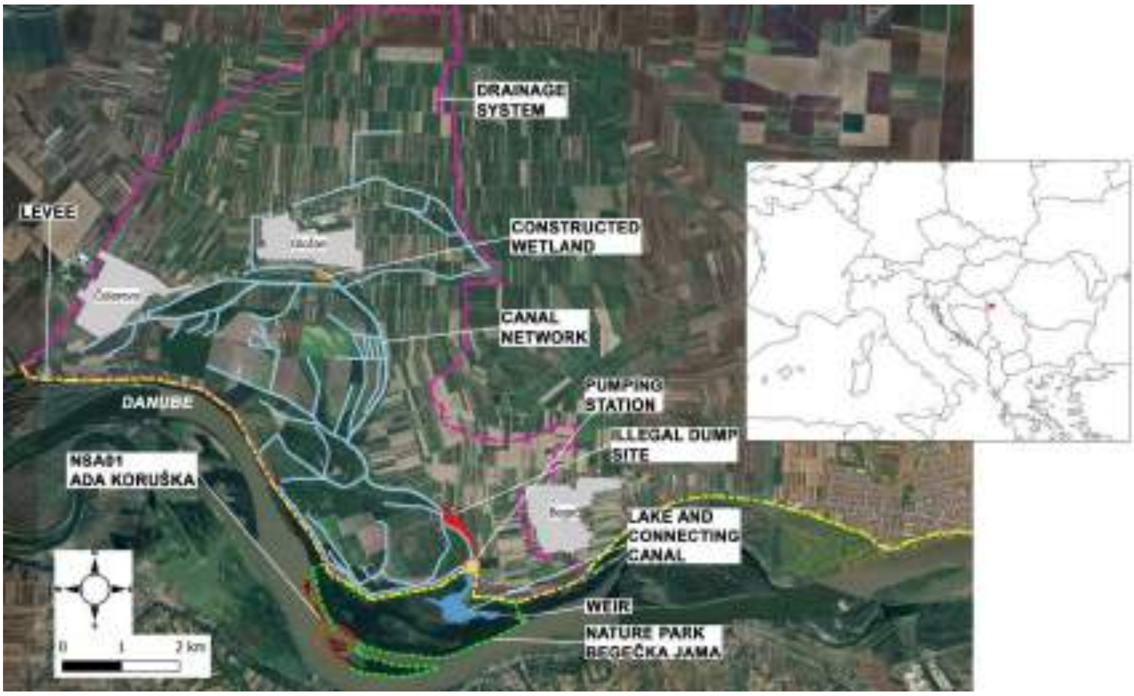

General overview of the area of the DPS 5 Begečka Jama (map made by Atila Bezdan)

Excess inland water, together with organic and inorganic pollutants from agricultural production, sewage from settlements and pollution from other sources, flows through the Tatarnica watercourse (the main channel of the drainage system) via the pumping station into the Begečka Jama. These pollutants pose a significant threat to the ecosystem of the Begečka Jama Nature Park.

The catchment area of the drainage system is about 4750 ha. The total length of the canal network is about 59 km, and the length of the main canal, the Tatarnica river, is 12 km. Excess water is pumped out of the drainage area by the pumping station, with a capacity of 2 m^3/s.

A short general overview of the **protected area** *Nature Park Begečka Jama*, is given in the next paragraph, based on the analysis and data presented in the following studies and reports: Institute for Nature Conservation of Vojvodina Province (2011) and **Danube Floodplain Project Reports** (https://www.interreg-danube.eu/approved-projects/danube-floodplain).

Begečka Jama Nature Park is an active floodplain located on the left bank between 1276.2 km and 1284 km of the Danube, 18 km west of the city of Novi Sad. The length of the area is approximately 7.8 km while the central point is 45° 13' 23"N, 19° 36' 23"E. It extends over an area of 379 hectares. The protected area contains a series of geomorphological forms of river erosion, including a fluvial lake and, consequently, a mosaic of wetlands in different stages of succession of floodplain vegetation. The survival of the wetland vegetation is due to the natural dynamics of flooding. A fluvial lake is connected to the Danube by a canal and has a constant presence of water. The length of the lake and the canal is about 1.8 km. The area is characterised by its **marshy-meadow vegetation and poplar plantations**. The special value of the vegetation of this area makes one white poplar and four black poplars very rear representatives of typical floodplain vegetation in Vojvodina, which are now protected as a nature reserve - the rare specimens of flora. In the area of the *Nature Park Begečka Jama*, about 150 **species of birds** can be observed, most of them migratory, transient and wintering. Apart from reveling in the countryside, it is also possible to go fishing. It is an extremely important **breeding ground for a large number of Danube fish species**, as well as a breeding centre for amphibians in the wider area. In accordance with the dynamics of flooding, micro, and meso-terrain configuration, **autochthonous forest communities**, **aquatic and wetland habitats** are present. Similar wetland- / floodplain areas are very common along the entire length of the Danube and its tributaries.

The following information on wildlife in this section is provided by the UNSFA Department of Animal Husbandry. They emphasise that the Nature Park Begečka Jama is under **state protection** and is a **significant natural asset** of the second and third category. It is an important habitat and breeding ground for **14 species of fish**, such as catfish, carp, pike, perch and others. It is a breeding ground for **11 species of amphibians** and **6 species of reptiles**. The area is also home to around **150 species of birds**. Some of them are red-headed swans, a symbol of Begeč, great cormorants, grey herons, etc. As the Begečka jama is located in an area of intensive agriculture, the problem of heavy metal pollution from phosphate fertilizers and pesticides in watercourses is real and needs to be monitored. The management of the Begečka Jama reserve has been transferred from the local hunting association to the rangers, and the ban on hunting all animal species has come into force. This is another reason for the need to monitor the growth of wildlife populations in the area. The increase in the population of wild species in the area of Begečka jama can also cause a kind of human-wildlife conflict. The presence of heavy metals in protected wildlife areas can also have a significant impact on both wildlife and the environment.

According to the Public Enterprise "Urbanizam" (2021b), the following **protected areas and ecological corridors** are located in the pilot area *Nature Park "Begečka Jama"* - protected area of regional importance; habitats of protected and strictly protected species of national importance "NSA 01, Ada Koruška"; River Danube - international and ecological corridor; River Tatarnica - local ecological corridor.

3.1.6. DPS6

Location: Sturgeon migration by-pass Iron Gates I and II, Bucharest

Short form of the organization: With more than 60 years of accumulated experience, the National Institute for Research and Development in Environmental Protection Bucharest (INCDPM) is a leading Romanian institution in the field of environmental protection and in the development of solutions for the sustainable use of resources and the services they provide. Its mission is to meet the needs of society in the fields of sustainable development, environmental protection, biodiversity conservation and climate change, at national and international levels.

General Overview

DPS 6 activities cover a Danube sector starting from the Danube Delta, where the river flows into the Black Sea, followed by all the Romanian and Serbian parts of the Danube, and ending on Hungarian territory at Danube km 1780. The proposed activities will be carried out in phases corresponding to the sections of the Danube to be assessed:

- → Scientific fishing will be carried out on the territory of Romania from the Black Sea to the Iron Gates II (up to km 863 of the Danube). In the region of the Iron Gates I, the innovative bypass measure will be implemented with the aim of resolving the disruption of the historical migration routes of anadromous sturgeon populations in the Danube caused by the hydrotechnical construction.
- → In order to validate the effectiveness of the proposed measure, monitoring and recovery activities of sturgeon ultrasonically tagged in scientific fishing campaigns will be carried out on the territory of Serbia from river km 1073 to km 1433 and on the territory of Hungary from km 1433 to km 1780.

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Location of the Danube sectors targeted by INCDPM in DPS6

The Iron Gates Natural Park (www.pnportiledefier.ro) corresponds to the IUCN category V - **Protected Landscapes** and represents a protected area established by the Romanian legislation in Law No. 5/2000 on the Approval of the National Land Use Plan - Section III a - Protected Areas (PR, 2000), as an area where the outstanding beauty of the landscapes and the biological diversity can be exploited under the conditions of unaltered preservation of traditions, and where the quality of life of the communities is the result of the economic activities of the inhabitants in permanent harmony with nature.

In accordance with the provisions of *Law no. 5/2000*, *Order* no. *552/2003* (MAPAM, 2003), *G.D.* no. *2151/2004* (GR, 2004) and *EOG no. 57/2007* (GR, 2007), the Iron Gates Natural Park includes 18 **protected areas/reserves**, of which those directly affected by the Iron Gates hydropower system are further detailed in the DPS6 document .

As part of the European ecological network NATURA 2000 in Romania, two Special Protection Areas have been proclaimed on the territory of the Iron Gates Natural Park in accordance with G.D. No. 1284/2007 (GR, 2007): **ROSPA0026 Danube – Baziaș - Iron Gates**, with an area of 10,124.4 ha and **ROSPA0080 Almăjului - Locvei Mountains**, with an area of 118,141.6 ha.

In addition, pursuant to Regulation no. 1964/2007 (MMDD, 2007), **ROSCI0206 Iron Gates**, an integral part of the European ecological network NATURA 2000, was declared a site of Community importance with a total area of 1,242,930 ha.

3.1.7. DPS7

Location: Danube Delta, Sulina Branch, Tulcea, Romania

Short form of the organizations: The UGAL - "Dunarea de Jos" University of Galati (UDJG) is a higher education institution in Romania. The university has a legacy with the Danube River and the Danube Delta (due to its location on the banks of the Danube) through its research activities. UDJG will be involved in this project through the REXDAN research infrastructure. REXDAN has the latest generation of powerful research equipment including a river research vessel. UDJG is involved in research areas related to water, sediments, soil, air, biodiversity, bathymetry, hydromorphology, etc., thus taking part in multiple domains including: chemistry, biology, physics, environmental science, ecology, bathymetry, topography, atmospheric chemistry, sustainable development, etc. UGAL's management is supported throughout the organization, helping to guarantee efficient feedback, and to ensure that all the necessary requirements, for the implementation of national and international projects, are met. It also helps to optimize operational management within the project consortia.

The National Institute of Hydrology and Water Management (NIHWM) is a public institution. It is the national authority in the field of hydrology, hydrogeology and water management. NIHWM develops research activities and provides operational services of national and international public interest for the protection and socio-economic well-being of people. The Institute's activities are very dynamic, constantly adapting to new needs and concerns.

General Overview

Location of the DPS 7: in the immediate vicinity of the mouth of the Danube into the Black Sea. (source: https://www.facebook.com/Dobrogea.Dobrogeni.Romania/photos/)

This map is intended to give an overview of the location of the DPS 7: the immediate vicinity of the mouth of the Danube into the Black Sea.

Located at the contact between the Danube River and the sea, it is considered as a "buffer zone" for the river-delta-sea system (Danube River - Danube Delta - Black Sea). At Ceatal Izmail, the Danube divides into two branches, the northern one, the Chilia branch, and the southern one, the Tulcea branch. The latter is divided, 17 km downstream, into two other branches, Sulina and Sfantu Gheorghe: the **Chilia branch**, the most important of this system, is 117 km long and forms the border with Ukraine. At its mouth it forms a secondary delta of about 24,000 hectares. The **Sulina branch**, 71.7 km long and extending another 8 km into the sea, located in the central part of the Danube delta, is the navigable branch as a result of numerous rectifications (from 1868 to 1902) and dredging works. It has reinforced parallel embankments (made of large boulders) to prevent the erosion of the banks caused by the navigation of ships. As the only canalised branch of the river, it connects the Danube with the Black Sea. The main purpose of building this huge system of dikes is to prevent the entrance to the Danube - the Sulina branch - from being blocked. Through this system of dikes, the northern current of the Black Sea is diverted to the north-northeast and the Danube alluvium cannot be deposited at the entrance of the navigable canal, but is directed to the sea, where the water depth exceeds 15-20 m. The **Sfântu Gheorghe branch**, the last branch of the Danube delta, is morpho-dynamically active and forms a secondary delta at its outflow into the sea.

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Sulina branch extended into the sea with stone embankments
(source: a) NIHWM, 2021; b) https://dunare.ro/sulina-oras-din-romania/bara-sulina/)
a) *b)*

The Sulina Branch is **extremely dynamic** from a morphological, hydrological and sedimentological point of view, due to its rectification, its dammed banks and especially to the presence of groins, which significantly influence the morphological evolution of the bed and the sediment transport from upstream to downstream. The Sulina branch is hydrologically monitored by 4 main hydrometric stations (h.s.), located at Ceatal Sfântu Gheorghe (sea mile 33.6), Crișan (sea mile 11.5), Sulina Port (sea mile 2.5) and Sulina Semnal Ceață (Hectometer Hm72+18m).

The analysis of the mean annual evolution of sediment volumes on the Sulina Branch aimed to highlight the temporal and spatial variability of the solid component between stations. It was found that from the entrance of the Sulina Branch to the exit, in the Black Sea, the solid input is constantly deposited annually, which is highlighted by the negative balance obtained on the areas between two consecutive stations located on the branch (h.s. Crișan - h.s. Ceatal Sf. Gheorghe; h.s. Sulina Port - h.s. Crișan; h.s. Sulina Semnal Ceață - h.s. Sulina Port). The largest alluvial deposits are recorded in the first 41 km (maximum 1.8x106 tonnes) and the most alluvial deposits, almost every year, in the last 11 km (maximum 0.5x106 tonnes).

The comparative analysis of the three sectors has shown that there is an alternation of the phenomena of deposition/erosion and allochthonous sediment sources between the analyzed sectors. Also, the solid input constantly deposited along the Sulina branch is evidenced by the negative balance between the outflow from the branch (h.s. Sulina Semnal Ceață) and the inflow to the branch (h.s. Ceatal Sf. Gheorghe), which reaches an average alluvial volume of $1{,}1 \times 10^6$ tons. The spatial analysis of the total volume of sediments along the Sulina branch, during the last 23 years (2000 - 2022), also shows a progressive decrease of the sediment volumes transported from the entrance to the Sulina branch to the exit to the Black Sea, i.e. a decrease of 36% (from 66.46 x106 tons to 42.77 x106 tons), while the total volume of water decreases only by 14%.

The analysis of the evolution of **water flows** for the period 2000 - 2022, at the Sulina Semnal Ceata Hydrometric Station, shows a decreasing trend in all three regime phases. In the case of the sediment discharge, the trend in the evolution of the maximum and minimum sediment flows is increasing, in conditions of a not very marked variability, considering the small differences in the values of the maximum sediment flows, between 113 kg/s (in 2003, 2011 and 2022) and 976 kg/s (in 2005), and especially the values of the minimum sediment flows in the range of 0.27 kg/s (in 2001) - 8.88 kg/s (in 2021). At the mouth of the Sulina branch the maximum flow of suspended matter does not exceed 1000 kg/s.

Evolution and trend of mean, maximum and minimum annual water and sediment discharge series for the period 2000-2022 at the hydrometic station Sulina Semnal Ceata

The **general characteristic of the soils** in the Danube Delta is the reduced development of the soil profile. In the area of the hydrometric station, the characteristic soils are protosols, alluvisols with different subtypes and psamosols. The soil texture varies from coarse to fine. It has a neutral to moderate reaction (pH = 7.5-8.4) and contains calcium carbonate from the surface. Granulometrically, the sand deposits become finer towards the surface, which proves that the alluvial power of the river has decreased over the years. The embankment of the city is subject to reflooding during high tides and easterly winds that block river discharge and sea level rise.

Considering the reduced supply of organic matter and macronutrients, the reduced capacity of the soil to store water and, therefore, the increased risk of drought, the **ecological value of alluvial soils** is moderate. Between the layers of sedimentary sand there are layers of sand containing peat. Historically, the alluvial banks, underwent great floods in the past, which carried alluvial suspensions, combined with rotten organic remains and horizons of dusty, saturated, loose mixtures, resulting in the geological combination of the ancient extended area of the Delta. **Histosols (organic**

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soils) support of the vegetation in the wet areas, where the reed beds and the submerged aquatic vegetation develop.

From the point of view of the shallow aquifer, in the area of Sulina, the **groundwater level** is at a depth of -1.50 m to -2.00 m, in the sand.

In the area of the Sulina canal, some **climatic records** have been established for Romania, including: the lowest haze; the highest solar radiation; the most sunny days; 225 days without frost; and the lowest annual rainfall (330-350 mm).

In the Danube drainage area, the particularly favorable **biological conditions**, created by the permanent or almost permanent presence of water, make the **luxuriant development of the vegetation**. The vegetation in this area is specific to the delta, composed of deciduous trees, shrubs and grasses, and also vegetation composed of agricultural crops.

At its confluence with the sea, the Danube River has formed, on an area of 5,800 km², one of the most important deltain Europe, the Danube Delta, which has been declared a UNESCO World Heritage Site, a Biosphere Reserve and a Wetland of International Importance (within the RAMSAR Convention). The study area, DPS7, is included in this large **protected area** (Danube Delta Reservation), which represents a protection zone for habitats and species, for water abstraction and aquatic species. Inside the Danube Delta there are small protected regions, regions that have been proposed for ecological reconstruction, fish farms, forestry regions, agricultural regions.

3.1.8. DPS8

Location: Bodrog River, Hungary

Short form of the organizations: The Plastic Cup Society (THU by its former name), originally founded in 1996 under the name Naturefilm.hu Society, began as a passionate team of nature filmmakers. The society produced an environmental television documentary series focusing on the problem of plastic pollution in the Tisza River. Its success led to the creation of a non-profit environmental initiative called Plastic Cup, which has since become a registered trademark and the official name of the society. Currently, Plastic Cup stands out as one of the most influential and effective river cleanup initiatives in the Danube River Basin due to its impressive results, large number of participants, and substantial outputs. This initiative goes beyond the simple act of cleanup. By emphasizing monitoring, education and recycling, it addresses different aspects of river litter and tailors its approach to each stage. These collective efforts have resulted in the removal of over 300 tons of river litter and the recycling of 200 tons of river litter, mostly plastics. While these activities have successfully raised awareness and engaged local stakeholders, the ultimate solution lies in preventing waste from entering the river. This requires the implementation of preventative measures and proper waste management systems. The Plastic Cup has therefore taken proactive measures in upstream countries, particularly in Ukraine. Along the Latorica and Uzh rivers, the initiative has established collaborative partnerships with local environmental activists and waste management companies. Together, they have effectively diverted more than 700 tons of household waste from the river.

The General Directorate of Water Management (OVF) is an independently operating institute and a central governmental body under the direction of the Minister of the Interior. OVF is based in Budapest, however the activities of the General Directorate of Water Management (OVF) cover the entire country. OVF coordinates the professional activities of the 12 local water directorates in Hungary.

General Overview

In DALIA, the DPS 8 site area includes the Hungarian section of the Bodrog River, from the border between Hungary and Slovakia to the mouth of the river at Tokaj, covering a distance of 51 kilometers along the river (abbreviated as "rkm"). The Bodrog River is one of the tributaries of the Tisza River, recognized as the longest (966 km) tributary of the Danube. The region is of particular importance from the project perspective due to the severe impact of transboundary litter pollution on the Tisza River, resulting in extensive contamination with various forms of plastic waste, including microplastics and macroplastic particles. In addition, the issue of legacy pollution, involving toxic substances leaking from abandoned mines, is equally significant. In 2000, the Somes River experienced a catastrophic cyanide spill, described by the BBC as "the worst environmental disaster since the Chernobyl nuclear leak in 1986". In 2022, the Slana River suffered months of poisoning that turned the entire river red. Both the Slana and Somes rivers flow into the Tisza, as does our pilot site, the Bodrog River, which collects water from tributaries such as the Latorica in Ukraine. To understand the severe plastic pollution of these waterways from improperly managed household waste, especially plastic, you can watch a **VIDEO** illustration filmed in March 2023 in the city of Munkachevo, Ukraine.

The Bodrog river basin. The activities of the pilot site will be carried out in the zone highlighted with yellow color (map: www.icpdr.org)

The Bodrog River is part of the Tisza River sub-basin and the Bodrogköz planning sub-basin within the Hungarian River Basin Management Plan (RBMP). The surface water body (SWB) code for the Hungarian section of the Bodrog River is HUAEP334. This water body belongs to the natural category and has specific typological characteristics, such as being a lowland river with a low gradient, a calcareous geochemical character with a medium-fine bed material. It also collects water from a relatively large catchment area. In Hungary, the Bodrog has a length of 51.2 km and a catchment area of 969.1 km². Its total catchment area is 12338 km². The average flow of the river from 1971 to 2000 was 119.6 m³/s. The Hungarian section of the Bodrog is a class III navigable waterway of regional importance. The Tiszalök dam on the Tisa River impounds the Bodrog from Tokaj (0 km) to Sárospatak (37 km). This dammed section is well adapted to the development of holiday cruises. From 2020, the section of the waterway between river kilometer 51 (HU/SK border) and 0 (Tokaj) can be navigated by a motorboat, small boats such as canoe, kayak, pedal boat, etc. (57/2011 (XI.22.) NFM decision), and thus also serves tourist purposes. Naturally a meandering type with an index of 0.85, although 32% of the riverbed is from the development of natural meandering progression constrained by reinforcement and 10% regulated: straightened and 19 groynes protect the riverbank from erosion. Nearly 35% of the river has an artificial barrier to protect deeper areas from flooding, thus reducing interaction with the floodplain. As there were no infrastructure or riverbed alterations associated with the pilot project, a standard map can be used. In addition, a hydrological model of the river is available to predict the spread of plastic pollution in the river (Fleit, G. et al 2023).

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Several sections of the Bodrog River are under **protection**. In Hungary, the Aggtelek National Park manages the Tokaj-Bodrog River **Protected Landscape Area**, which is one of the most beautiful wetlands in the country. Any activity in the area requires a permit. This is the only area in the country that is regularly flooded. Apart from its natural values and undisturbed nature, this is one of the reasons why it was included in the list of internationally significant waterbird habitats under the Ramsar Convention in 1989. The area was declared protected in August 1986 and covers an area of 5318 hectares. It consists of two main parts. One is the Nagy-Kopasz, which belongs to the Tokaj-Hegyalja region, famous for its flavorful wines, and is part of the UNESCO World Heritage. With a height of 513 meters, it is one of the largest volcanic hills in the country. The other important area of the protected landscape is the Bodrog-Tisza floodplain, which is silvery in spring due to the swollen and glistening waters of the two rivers. As a result, the vegetation here is dominated by plant species associated with water and wet habitats. Because of the spring floods, the floodplain remains inaccessible until mid-summer, providing undisturbed nesting habitat for the rich waterfowl population. Numerous species of ducks and waders, such as the elegant great egret, its smaller and rarer cousin the little egret, or the elusive bittern, which nests in the sedge and wet meadows, have made the Bodrogzug internationally famous. During the fall migration, large flocks of southward-migrating waterfowl pass through or congregate in the area. The list of basic data concerning the Tokaj-Bodrogzug Protected Landscape Area includes the following: Registration number: 183/TK/86 Legal regulation declaring the protection: 165/2007 (XII. 27.) Government Decree on the Protection of the Tisza-Bodrog-Tisza Corridor Number of areas covered by international agreements: HUBN10001 Bodrogzug-Kopasz-hegy-Taktaköz Special Area of Conservation for Birds Natura 2000, HUBN20072 Tokaji Kopasz-hegy, HUBN20071 Bodrogzug and Bodrog floodplain Special Area of Conservation for Birds Natura 2000; RAMSAR site (3782 ha) Area: 5058 ha (strictly protected: 724 ha) County name: Borsod-Abaúj-Zemplén County Names of settlements: Bodrogkeresztúr, Bodrogkisfalud, Olaszliszka, Szegi, Tarcal, Tiszaladány, Tokaj, Zalkod Geographical coordinates (EOTR) N: 48° 15'; E: 21° 25' Height above sea level: max.: 513 m, min.: 93 m.

3.1.9. DPS9

Location: “Crișuri" River Basin, Romania

Short form of the organization: The CWBA - Crişuri Water Basin Administration is located in the western part of Romania. It manages the waters on the territory of the "Crișuri" River Basin in public domain and the infrastructure of the water management system, which consists of reservoirs, flood control dams, inter-basin discharges, water abstractions and other specific hydrotechnical works. In addition, they manage hydrological, hydrogeological infrastructure, in addition to performing quality monitoring of water resources in its heritage, in order to better understand and manage surface and groundwater resources.

General Overview

The Crisuri Water Basin Administration (DPS 9) proposed to implement some intervention sections at the basin scale for waste management and watercourse cleaning through the installation of three litter traps. The aim is to reduce pollution from PET (floating plastic bottles or similar) in the transboundary zone on three main watercourses. The three main watercourses are the Barcău River with a length of 134 km, the Crișul Repede River with a length of 71 km and the Crișul Negru River with a length of 164 km.
They are all 1st and 2nd order tributaries of the Hármas Körös, which in turn is a tributary of the Tisza.

Crișuri Catchment Area related to Tisa, tributary to Danube

Proposed litter trap placements in Crișuri Catchment Area (DPS 9)

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All three rivers covered by this DPS intersect **Natura2000 sites** (https://natura2000.eea.europa.eu/) along their course, but for the purposes of our work in Dalia, we'll only mention those that fall within our 'zone of interest'.

The location of the **Barcău river litter trap** doesn't overlap with any Natura 2000 sites, as it is located 3.5 km upstream of **ROSPA0067 Lunca Barcăului - Barcău's meadow** (protected under the Birds Directive).

On the other hand, the **Crișul Repede river litter trap** overlaps with 2 Natura2000 sites, the **ROSCI0104 Lunca Inferioară a Crișului Repede - Crișul Repede's inferior Meadow** (protected under the Habitats Directive) and **ROSPA0103 Valea Alceului - Alceu's Valley** (protected under the Birds Directive).

Lastly, the **Crișul Negru river litter trap** is located within the Natura2000 site **ROSCI0049 Crișul Negru** (protected under the Habitats Directive).

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3.2. Results of questionnaires

DPS-1: Szigetköz

1. *Short description of DPS emphasizing the part of the pilot that is planned to be replicated (keep in mind that the budget for replication is 100.000 euros).*

Designing guidelines for putting principles into practice when designing **the rehabilitation of heavily modified water bodies are recommended for replication**. These guidelines help to apply an open-design approach by involving stakeholders in order to resolve existing conflicts, create compromises, and achieve a consensus.

<u>Short description of DPS-1:</u> Heavy modifications made water replenishment in the Szigetköz area unable to sustain the floodplain environment and other water uses within the region by the late 1900-s. In turn, the operation of the Gabcikovo Power Plant by Slovakia in 1992 made redesigning the replenishment system necessary. It marked the starting point of a 30 year process of rehabilitation in the Szigetköz active and inactive (historical) floodplain. The rehabilitation actions were based on restoring water levels of a reference period, which was determined together with the stakeholders of the area. Water replenishment to restore water levels of the reference period was accomplished with a gravitational system, using the Dunakiliti barrage and several submerged weirs, and other hydraulic structures. These engineering facilities make it possible to control the water replenishment systems dynamically, following the natural daily fluctuations of the Danube River. Longitudinal and lateral ecological connection between separated waterbodies of the floodplain water replenishment systems is provided by numerous fishpasses each with a unique design to fit the specific location.

Further innovative elements of planning and operating of the system, which can also be considered for replication include:
(1) dynamic control of the system;
(2) stakeholder involvement practices during planning and operation; and
(3) design aspects of different fish passes, which are described in more detail with the Factsheet of DPS-1.

2. *What kind of data did you need to gather before you created, developed and installed your DPS? What kind of hydrological, climatic, environmental, socio-economic data?*

Hydrological (time-series data) for
- surface water levels and discharges
- residence times of water in the branch system
- groundwater levels

These are needed in order to characterize the reference period for rehabilitation activities, and for achieving good ecological potential.

Environmental and socio-economic indicators (ecosystem services):

agricultural land	- yields [t/ha]
tourism	- canoe rental firms
	- historical floodplain beaches [water cover: yes/no]
ecological functions	- fish-species
forestry	- forest growth [m^3/ha]

These are needed in order to highlight the effects of heavy modifications in the current state, and also to serve as a baseline when monitoring the effects of rehabilitation activities.

3. *Describe what goal can be achieved with replication of DPS? What will be the expected outcomes/expected changes and potential benefits of that replication? If possible, please try to list at least one benefit in each of the following categories:*

   ☒ water related – effective and integrated water resources management by involving stakeholders in the decision-making process.

   ☒ environmental – water status (hydromorphological, chemical and ecological) improvement, reaching good ecological potential, increased biodiversity.

   ☒ socio-economic – growing acceptance between different water management goals (navigation, hydropower generation, irrigation, tourism, fishing); harmonizing different water management activities in space and time, resolving conflicts.

4. *What criteria should be analyzed when deciding where to replicate your DPS (part of DPS with value about 100.000 euros)? Please try to list everything what is relevant? For instance, try to list at least one criterion for each of the following categories:*

   ☒ **hydrological criteria**
   - riverine environments, which are heavily modified (according to the terminology of the EU-Water Framework Directive) by hydrological alterations, such as
     - floodplain divided by flood-protection levees
     - water abstractions or diversions
     - hydropower generation
     - river regulation / channelization

   ☒ **geomorphologic criteria**
   - once interconnected water bodies which are now separated or having limited connection (e.g. only during short periods, like flood events) due to heavy modifications
     - main branch – side branch systems
     - river – hydropower diversion canal
     - meandering river – natural or man-made oxbow lakes

   If necessary, we can give additional criteria, but we didn't want to narrow down the search too much, because the recommended replication actions can be used quite generally!

5. *How would you measure previously listed criteria (define what type of attributes: natural, proxy or constructed)? For definition of attributes see description below in italic:*

   Heavy modification caused by hydrological alterations:

RBMP classification (constructed)

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surface water levels (proxy) surface water discharges (proxy) groundwater levels (proxy)

Once interconnected water bodies, which are now separated or having limited connection:

digital elevation maps (natural) cross sections (natural) longitudinal sections (natural) + location of hydraulic structures (proxy)

6. *To your best knowledge, is it easy or complicated to obtain data for previously listed criteria and attributes for other associated regions?*

☒ **hydrological criteria** (water quantity, type of river: lowland, mountain river, etc.):

- Heavy modification caused by hydrological alterations:

RBMP classification **(easy)** surface water levels **(moderately difficult)** surface water discharges **(moderately difficult)** groundwater levels **(moderately difficult)**

☒ **geomorphologic criteria**

- once interconnected water bodies which are now separated or having limited connection (e.g. only during short periods, like flood events) due to heavy modifications

digital elevation maps **(moderately difficult / difficult: depending on spatial resolution)** cross sections **(moderately difficult)** longitudinal sections **(moderately difficult)** + location of hydraulic structures **(moderately difficult)**

7. *What are the limitations where your DPS may be replicated? For example, for pilot-constructed wetland replication criteria are settlements with less the 5000 citizens, locations where exist empty lot of size more than 2 ha.*

No further limitation other than the previously listed criteria.

8. *Please suggest specific locations (minimum 5) where your pilot may be replicated (for each location, explain why you think it is suitable to be a replication location in more detail as possible; what are the conditions that make it perfect for your pilot; do you have data for that location and which one (for example climate, natural conditions, socio-economic data, etc.).*

Regions in which water resources management needs to be reconsidered, because of new water uses and/or the need of taking into account new requirements of good ecological potential:

COUNTRY	**AUSTRIA**
River:	**Drava River**
Area(s):	Rosegg
	Kleine Drau – Feistritz im Rosental
River:	**Gail River**
Area:	Arnoldstein-Erlendorf
River:	**Mura River**
Area(s):	Mixnitz
	Mellach
	Spiefeld

COUNTRY	**SLOVENIA**
River:	Drava River
Area:	Maribor

COUNTRY	**CROATIA**
River:	Drava River
Area(s):	Sveta Maria
	Semovec
	Donje Vratno-dio

COUNTRY	**POLAND**
River:	Vistula River
Area(s):	Laczany

9. *Now, use objectives/criteria from question 4 to guide the search for locations (associated regions). Focus first on each objective/criterion one at a time and ask yourselves, what are some locations that might measure up well in terms of this objective? Then one considers sets of more than one objective and asks an analogous question. For instance, ask yourself which locations can be good for replications according to water quality criterion? Then, which locations can be good for replications according to hydrological criterion? Etc.*

We answered question 8, according to the criteria described in questions 4, 5.

10. *For listed locations, try to provide estimation if it is possible to obtain data related to previously listed criteria/objectives.*

RBMP data, and hydrological, geomorphological data, and data on existing hydrological structures can be obtained from regional water authorities / water directorates.

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DPS-2: Reconnected Floodplain – Ingolstadt (Germany)

1. *Short description of DPS emphasizing the part of the pilot that is planned to be replicated (keep in mind that the budget for replication is 100.000 euros).*
   - Creating a new river, which flows from the Danube through the floodplain forest and returns to the Danube (costs exceed 100.000) (aim: lateral & longitudinal reconnection)
   - Reconnect of oxbow-lakes with the Danube (main river)
   - Controlled ecological floodings with a sluice gate (in a dike) (aim: lateral connectivity of river during flood events)
   - Ground water lowering for permanent wet areas (aim: to get more water level dynamics for typical riparian vegetation on muddy banks)
   - Fish ladders and fish passages (aim: longitudinal connectivity for fishes)
   - Monitoring system for vegetation, hydrology and geomorphology (aim: monitor and verify the differences and success of the re-dynamization project)

   In our case, a **feasibility study** was financed from 100,000 euros at the beginning of the project. The study results predicted that there would be no major problems and that the project would succeed, and therefore applications for the project could be submitted.

2. *What kind of data did you need to gather before you created, developed and installed your DPS? What kind of hydrological, climatic, environmental, socio-economic data?*

   - Groundwater data for the area
   - Discharge of the river (Danube)
   - Geodata (DGM) + satellite data of the area to identify dry river channels, which could be reconnected
   - Geological data: Where are gravel layers? (this influences the distribution of the groundwater level)
   - Feasibility study: data for the vegetation, birds, beetle, amphibian, fish, dragon fly -> result: bad ecological status of the floodplain vegetation -> need to change to protect the ecosystem

3. *Describe what goal can be achieved with replication of DPS? What will be the expected outcomes/expected changes and potential benefits of that replication? If possible, please try to list at least one benefit in each of the following categories:*
   - ➔ **socio-economic:**
     The area is equipped with several information boards that provide information about floodplains and the renaturation measures. Citizens can walk or cycle along various floodplain circuits and this raises awareness among the population. It is a beautiful area where people now like to go and relax.

   - ➔ **Environmental: Lateral & longitudinal reconnection of river and floodplain area**

- Restoration of lateral and longitudinal connectivity between river and floodplain (retention area).
- Ecological flooding promotes the typical floodplain vegetation on and in the river and creates a diverse mosaic of different habitats.
- This also has an impact on amphibians and fish, which find new spawning habitats in the floodplain forest and can now migrate. Restoration of typical fauna of the floodplain.
- In addition, the new dynamics of the Ottheinrichbach create new habitats for flora and fauna, such as gravel islands.
- Plants of alluvial forests are adapted to dispersal through a stream (hydrochory). Therefore, the floodplain river helps the dispersal and preservation of typical species and also transports their seeds along the river to new areas.

➔ **water related:**
- Dynamization of the groundwater level.
- Through the shadow of the riparian forest the water is cooled in the small river.
- Water retention during flood events.
- Sediment retention in the floodplain.
- New gravel is added to the main watercourse through erosion processes in the riparian forest

4. *What criteria should be analyzed when deciding where to replicate your DPS (part of DPS with value about 100.000 euros)? Please try to list everything what is relevant? For instance, try to list at least one criterion for each of the following categories:*

➔ **hydrological criteria** (water quantity, type of river: lowland, mountain river, etc.):
- o Groundwater data for the area
- o Discharge of the river
- o type of river: Lowland river

➔ **Geomorphological & geological criteria:**
- o geodata (DEM) + satellite data of the area to identify dry river channels, which could be reconnected
- o Location gravel layers (this influences the distribution of the groundwater level, material (gravel deposit) near the river that can be relocated)

The following is recommended for the analysis.

Very important:

a) Search for a **transverse structure** in a river:

➔ Google Maps / Earth (search for hydropower plant, dam, bottom ramp and other transverse structures), Datasets from Danube GIS (ICPDR), Barrier App for Smartphone: Amber Barrier Tracker (only 60ilometr barriers)
Very good: https://www.danubegis.org
With this website you can see, if fish can pass a transverse structure and you get more information about the structure. You can also see the planned measures. Many plans are to be implemented by 2027 (WFD). The willingness would be there, and we could support this with our Dalia budget!

➔ Amber Interactive map: https://amber.international/european-barrier-atlas/

b) Look at the transversal structure: Is the longitudinal and lateral connectivity disturbed by the transverse structure? **Is there already a bypass stream**?

Important: But then **you also need a floodplain forest with the problem of not getting enough water**.

If there is a bypass stream, you can consider building a sluice into the dam. This could replicate ecological flooding. The floodplain forest should be morphologically lower to the surrounding land so that the infrastructure is not damaged.

- ➔ Look at Geodata (Corine landcover from 61ilometre61: floodplain classification, riparian zone dataset from copernicus: MAES classification), if there is a floodplain forest area and how big it is
- ➔ For ecological floodings: Is the next infrastructure far away?

c) Check, if it is a protected area and if it is possible to do construction work

5. *To your best knowledge, is it easy or complicated to obtain data for previously listed criteria and attributes for other associated regions?*

   - It is easy to identify transverse structures via geodata.
   - With the help of the MAES classification (riparian zone dataset from copernicus) it should also be unproblematic to find out whether there is a riparian forest in this area.
   - Then it still has to be checked whether a bypass stream is already present. This can also be done visually via a map.
   -It is more problematic to find out what negative impacts the transverse structures cause in the respective area.

6. *What are the limitations where your DPS may be replicated? For example, for pilot-constructed wetland replication criteria you should find settlements that have less the 5000 citizens, and where an empty lot of size more than 2 ha exists.*

   - ➔ Limitation for ecological floodings: The floodplain forest should be morphologically lower to the surrounding land so that the infrastructure is not damaged.

   - ➔ Limitation for the floodplain by-pass-stream: The floodplain forest area must be large enough to overcome the height difference of the transverse structure. The slope of the bypass stream shouldn't be too high.

7. *Please suggest specific locations (minimum 5) where your pilot may be replicated (for each location, explain why you think it is suitable to be a replication location in more detail as possible; what are the conditions that make it perfect for your pilot; do you have data for that location and which one (for example climate, natural conditions, socio-economic data, etc.).*

We used https://www.danubegis.org to find barriers, where fish can't migrate. Here 5 examples:

Nr. 1: Austria

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On the red triangle you can see a transverse structure, which is not passable for fish.

On the left site are the information for this structure.

Nr. 2: Austria

48° 23' 09.56183" N 14° 01' 25.18187" E

Alteration of River Continuity for Fish Migration (1/1)

COUNTRY	Country	AT: Austria
EUCD_LO_IN	Continuity interruption ID	AT661BE595-52F3-4A92-A0A3-79EEC1B73B54
REPORT_TYP	Report type	BOTH: Report according to both EU WFD Art. 5 & 13
LO_IN_TYPE	Type	D: Dam/weir
US_LO_IN_1	Main usage	H: Hydropower
WAT_L_DIFF	Water level difference (m)	15
FISH_AID	Fish migration aid	N: No, not passable for fish
CONT_MEAS	Expected measures	Y: Measure implementation by the end of the next WFD reporting cycle
DECIS_HMWB	Decisive for HMWB	U: Unknown
EUCD_RIV	River ID	AT130
RIVER_NAME	River name	Donau
EUCD_RWB	River Water Body ID	ATOK410360003
RWB_NAME	River Water Body name	Donau-Aschach
RWB_TYPE	Designation of river water body	H: Heavily modified water body
MEAS_CLASS	Classification of expected measures	Implemented by 2027

Nr. 3: Austria

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48° 14' 52.46118" N 14° 25' 56.47118" E

Alteration of River Continuity for Fish Migration (1/1)

COUNTRY	Country	AT: Austria
EUCD_LO_IN	Continuity interruption ID	ATD8980AB5-3A08-4804-820B-0901BD36A6A7
REPORT_TYP	Report type	BOTH: Report according to both EU WFD Art. 5 & 13
LO_IN_TYPE	Type	D: Dam/weir
US_LO_IN_1	Main usage	H: Hydropower
WAT_L_DIFF	Water level difference (m)	11
FISH_AID	Fish migration aid	N: No, not passable for fish
CONT_MEAS	Expected measures	Y: Measure implementation by the end of the next WFD reporting cycle
DECIS_HMWB	Decisive for HMWB	U: Unknown
EUCD_RIV	River ID	AT130
RIVER_NAME	River name	Donau
EUCD_RWB	River Water Body ID	ATOK410360007
RWB_NAME	River Water Body name	Donau_10, KW Ottensheim_Wilhering bis KW Abwinden_Asten, EP groß
RWB_TYPE	Designation of river water body	H: Heavily modified water body

Nr. 4: Austria

48° 11' 22.96125" N 15° 04' 20.30406" E

COUNTRY	Country	AT: Austria
EUCD_LO_IN	Continuity Interruption ID	AT95C7D7D1-0856-4F26-BCEC-32253C30E4D9
REPORT_TYP	Report type	BOTH: Report according to both EU WFD Art. 5 & 13
LO_IN_TYPE	Type	D: Dam/weir
US_LO_IN_1	Main usage	H: Hydropower
WAT_L_DIFF	Water level difference (m)	11
FISH_AID	Fish migration aid	N: No, not passable for fish
CONT_MEAS	Expected measures	Y: Measure implementation by the end of the next WFD reporting cycle
DECIS_HMWB	Decisive for HMWB	U: Unknown
EUCD_RIV	River ID	AT130
RIVER_NAME	River name	Donau
EUCD_RWB	River Water Body ID	ATOK410360012
RWB_NAME	River Water Body name	Donau_08, KW Wallsee_Mitterkirchen bis KW Ybbs_Persenbeug, EP groß
RWB_TYPE	Designation of river water	H: Heavily modified water body

Nr. 5: Slovenia

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46° 24' 32.00252" N 14° 07' 42.89174" E

COUNTRY	Country	SI: Slovenia
EUCD_LO_IN	Continuity Interruption ID	SISI40
NAME	Name	Pregrada HE Moste
REPORT_TYP	Report type	BOTH: Report according to both EU WFD Art. 5 & 13
LO_IN_TYPE	Type	D: Dam/weir
US_LO_IN_1	Main usage	H: Hydropower
WAT_L_DIFF	Water level difference (m)	48
FISH_AID	Fish migration aid	N: No, not passable for fish
CONT_MEAS	Expected measures	Y: Measure implementation by the end of the next WFD reporting cycle
DECIS_HMWB	Decisive for HMWB	N: No
EUCD_RIV	River ID	SI1
RIVER_NAME	River name	Sava
EUCD_RWB	River Water Body ID	SI111VT7
RWB_NAME	River Water Body name	MPVT zadrževalnik HE Moste
RWB_TYPE	Designation of river water body	H: Heavily modified water body

8. *Now, use objectives/criteria from question 4 to guide the search for locations (associated regions). Focus first on each objective/criterion, one at a time and ask yourselves, what are some locations that might measure up well in terms of this objective? Then consider sets of more than one objective and asks an analogous question. For instance, ask yourself which locations can be good for replications according to water quality criterion? Then, which locations can be good for replications according to hydrological criterion? Etc.*

&

9. *For listed locations, try to provide estimation is it possible to obtain data related to previously listed criteria/objectives.*

With the help of the Danube GIS, the possible associated regions in the Danube catchment area are easy to find. It is still important to find out whether there is a floodplain forest around the transverse structure. At least with the focus on a re-dynamization of the groundwater level with reference to the typical riparian forest vegetation. In terms of longitudinal connectivity, all transverse structures can be used where there is no continuity for aquatic life.

Our criteria such as groundwater or geological criteria are too specific to be easily read off a map. This information must then be verified in situ in the selected area before the measure is implemented.

DPS-3: Dyje sub-catchment

1. *Short description of DPS emphasizing the part of the pilot that is planned to be replicated (keep in mind that the budget for replication is 100.000 euros).*

Having in mind the replication funds limit, we propose a floating evaporimeter station(s) to be placed at the site in order to improve the precision of water evaporation from the water body. The DPS3 contains surface water bodies that are significant to the region by providing for industrial, tourism, nature conservation, agricultural and economic activities. At the DPS3 directly connected to the water body, there is a system of interconnected protected sites, soon to be changed to a single protected area – large floodplain forest. The system is managed in terms of water with the use of many elements (weirs, dikes, embankments), which took years to build, not to mention the investment size. The forest demands artificial flooding from the reservoir (could add up to 1/3 of the whole capacity) at least once in several years to maintain its ecosystem services.

In conditions of climate change, there is an increase in the average air temperature, which has a direct effect on the increase in evaporation. Based on the data measured so far and the predictions of climate scenarios, there will not be a significant increase in precipitation; rather it will remain the same. From these points of view, it can be assumed that water losses from the basin due to evaporation will play an increasingly important role in the overall hydrological balance of the territory. Such losses are at the potential at the water surface.

The basin where the catchment is located (Thaya) spreads across diverse landscapes, but does not stream in the mountains, rather in the highlands, which do not receive as much winter snow precipitation in the last couple of decades. Combined with higher mean annual temperatures propagate towards an increase in evaporation and plant transpiration. As a current practice within the legal framework in Czechia, the handling rules of large reservoirs do have a constant evaporation rate for each month, which was estimated decades ago and may not be representative today. Since the water balance is afterwards calculated using these rough estimates, it can lead to significant distortion in calculation of the reservoir inflow and withdrawals capacity. The differences could be in tens of percent per month.

As a new approach, floating evaporimeters are used to determine water loss through evaporation, which measure the current evaporation from the water level directly on the water reservoirs, so there is no error in the calculation when determining evaporation based on formulas dependent on derived meteorological data.

The floating evaporimeter consists of a mechanical structure, which includes a measuring vessel with a diameter of 620 mm, floats and breakwaters. Powered by a battery charged by 2 solar panels (each 20W). Completed with a two-way pump that fills/drains water into/from the evaporative container in the event of a level change from the reference value by 5 cm.

Sensor equipment:
- universal multi-channel monitoring unit with GSM/GPRS module
- Accurate level sensor of the vaporizer, range 0-400 mm
- Relative air humidity and air temperature sensor
- wind direction sensor
- Anemometer in all-metal design

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- water temperature sensor, four-wire connection
- rain detector with controlled heating
- Net Kipp & Zonen radiometer

Data are recorded at 10-minute intervals and sent to the server 3 times a day at 1:00-7:00-19:00 based on GSM data transmission. Evaporation and precipitation are measured based on a 1-minute record of the water level in the evaporative container in combination with a rain detector and information on water intake/discharge into/out of the container. Average daily values of meteorological variables are calculated as an average of 10-minute measurements on a given day. Evaporation and precipitation values are derived from 1-minute records.

Monitored meteorological quantities:
Evaporation [mm], precipitation [mm], solar radiation [W/m^2], air temperature [°C], water temperature in the evaporimeter [°C], water temperature at depths 0.5-1-1.5-2- 2.5 m [°C], wind speed [m/s], instantaneous wind speed [m/s], wind direction [0-360°], relative humidity [%].

The purchase of a floating evaporimeter costs up to 20,000 Euros in the Czech Republic. By using multiple measuring devices, it is possible to achieve a significant refinement of the 68ilome values in a specific area, and from the data, for example, determine formulas for calculating 68ilome from meteorological monitoring data. The system itself contains a battery and solar panel, hence it is largely self-sufficient and does not need to be controlled frequently. If the equipment is placed at a locality with icing/freezing during winter, it has to be removed prior and reinstalled after thaw. The maintenance cost is therefore dependent mostly on the personnel costs. The replicator has to account for the specificity of installation of such a device. The floating evaporimeter needs to be physically bonded to the bed either by anchors or pylons. The evaporimeter is a large and heavy installation needed to be carried and moved on a carriage. See below.

2. *What kind of data do you needed to gather before you created, developed and installed your DPS? What kind of hydrological, climatic, environmental, socio-economic data?*

No specific data is needed in order to install the equipment. For a large water reservoir, the replicant should take the depth into consideration, since the device has to be anchored. For deciding where to place the equipment, the following should be assessed.

Hydroclimate time series or equivalent in spatial products availability:

- discharge measured at least at the system outflow,
- climate variables, time series in the minimum of daily sum of precipitation, and daily average temperature,

Environmental and socio-economic

- Water systems management plans, irrigation demand, local nature conservation care plans, stakeholder's economic investments planned in the vicinity, water demand by industry and municipality.

It would be beneficial to obtain the methodology used to calculate evaporation from the water surface. The results obtained would be compared with the data directly measured by the floating evaporimeter.

3. *Describe what goal can be achieved with replication of DPS? What will be the expected outcomes/expected changes and potential benefits of that replication?*

In general, achieve/maintain stakeholder's interests by balancing between tourism, forestry, agriculture and nature conservation water demand.

☒ **Environmental**
When increased water loss through evaporation due to the progress of climate change is detected, action can be provoked in the introduction of complex adaptation measures for retaining water in the landscape, increase in biodiversity
The floodplain forest needs periodical flooding to maintain a healthy forest ecosystem and to fulfil the nature conservation role.

☒ **Socio-economic**
Flooding also causes temporary occurrences of mosquito swarms thus harming tourist season and local economy. Swarms pose a threat in possible disease outbreaks.

☒ **Water related**
When increased water loss through evaporation due to the progress of climate change is detected, action can be provoked in the introduction of complex adaptation measures for retaining water in the landscape, and to increase in 69ilomet diversity.
Flooding needs not only investment in the infrastructure, but at given dry years it is not possible due to the already tight water balance resulting from higher evaporation rate and lesser winter precipitation.

4. *What criteria should be analysed when deciding where to replicate your DPS (part of DPS with value about 100.000 euros)? Please try to list everything what is relevant? For instance, try to list at least one criterion for each of the following categories:*

☒ **hydrological criteria** (water quantity, type of river: lowland, mountain river, etc.); Water body, large enough to be significant in terms of regional center (via water demand).

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- ☒ **climate criteria**; Water limited catchment either with seasonality and high evaporation in the summer, or high evaporation through the whole year.
- ☒ **soil criteria**; No specific soil criteria
- ☒ **geomorphologic criteria**; High evaporation occurs more probably in lowlands – elevation.
- ☒ **vegetation criteria**; We don't see the need for the replicator to host the same vegetation – floodplain forest, could be a general rural/agricultural area or even industrial/urban.
- ☒ **water quality**; No criteria imposed
- ☒ **socio-economic criteria**; The water body (bodies) should be a significant source for local business be it tourism, fisheries, agriculture or industry, where 70ilometre evaporation estimate makes a difference There is no clear objective how to state the relative importance other than the size of the water body.
- ☒ **tourism**
- ☒ **recreational**
- ☒ **wildlife**, etc

5. *How would you measure previously listed criteria (define what type of attributes: natural, proxy or constructed)?*

   For the elevation we propose in general "lowlands".
   For the size we think the WB(s) should have at least 10 km^2 in size in total.

6. *To your best knowledge, is it easy or complicated to obtain data for previously listed criteria and attributes for other associated regions?*

   The climate data set can be obtained through multiple sources. Usually, the national weather service provides meteorological variables like daily or monthly total precipitation, minimum, maximum and average temperature. Obtaining those could be fairly easy to moderately difficult. Defining the limitations of water abundance could be hard, since maintaining a water withdrawals database may not be mandatory in all countries. Calculation of water balance is easy if the listed data are available. Identification of "water-limited WB" may not be easy, we can help.

   Reservoir handling rules have to be obtained from the dam operator, which could be difficult.

7. *What are the limitations where your DPS may be replicated? For example, for pilot-constructed wetland replication criteria are settlements with less the 5000 citizens, locations where exist empty lot of size more than 2 ha.*

   Other than the long-term water deficit (as described) and large enough surface water body (or a collection of water bodies), we do not feel that any hard limitations prevent replication.

8. *Please suggest specific locations (minimum 5) where your pilot may be replicated (for each location, explain why you think it is suitable to be a replication location in more detail as possible; what are the conditions that make it perfect for your pilot; do you have data for that location and which one (for example climate, natural conditions, socio-economic data, etc.).*

We could provide climate data from RS sources; we cannot provide discharge data or handling rules of reservoirs. The possibility of replication could be actually very broad, but in general it is reasonable to select a locality which is already instrumentalized and at least some of the variables of hydrological balance are measured. Most commonly it is the gauging stations to streamflow, meteorological station and shallow boreholes. It also makes sense to select a place with tight water balance, so that precision in estimation makes a difference to the stakeholders.
Austria – Neusiedler See
Bosnia – Ribniak Saničani
Croatia – Ilova river catchment
Poland – Otmuchow lake

9. *Now, use objectives/criteria from question 4 to guide the search for locations (associated regions). Focus first on each objective/criterion one at a time and ask yourselves, what are some locations that might measure up well in terms of this objective? Then one considers sets of more than one objective and asks an analogous question. For instance, ask yourself which locations can be good for replications according to water quality criterion? Then, which locations can be good for replications according to hydrological criterion? Etc.*

   The proposed locations all fit well within the stated criteria. We intentionally posed very loose criteria.

10. *For listed locations, try to provide estimation is it possible to obtain data related to previously listed criteria/objectives.*

    Hydrological data should be obtainable from local or state authorities. Climate variables as well, or series could be derived from pan-regional or global RS products. Obtaining elevation is easy, data from authorities may be difficult to get and vary state to state.

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DPS-4 Upper catchment of Vah River

Description of the replicable segment of their DPS, taking into account a maximum budget of 100,000 euros.

Nature-based water retention measures to slow down rainfall runoff and increase water infiltration. These measures will increase water flows during droughts, decrease culminations of flash floods, mitigation of forest fires, improve thermoregulation, and support biodiversity.

Enumeration of criteria crucial for the successful replication of said segment of DPS.

- Direct measure: Cubic meters of ad interim retained water
- Impact measures:
    - More water available during rainless periods;
    - Lower flash flood culminations;
    - Less frequent and less harmful forest fires; and
    - Increased biodiversity, more comfort during hottest days.

Suggestion of an initial set of locations (outside of DALIA consortium countries) where their DPS segment could be replicated.

The DPS could be replicated on upper catchments (mainly spring area) where is water shortage during droughts, and/or flash flood risks. We would look at (examples, we can provide more details if needed):

- Ukraine (mainly Zakarpattia region),
- Poland,
- Belgium (area of recent catastrophic floods),
- Germany (eastern),
- Spain (Katalonia region),
- France (Lyon),
- Grece (Atika region),
- Slovenia,
- Croatia,
- Algeris,
- Azerbaijan,
- Italy,
- Arabian peninsula (Oman).

How far can EUR 100,000 go?

It depends on many factors, mainly the local labour costs. Generally, they should be able to cover (EU averages) approximately 78 hectares with NBS measures, retaining 4,600 cubic meters of water on forest land. The agricultural land requires a much higher measure density so the replication would cover 12 hectares of arable land or 23 hectares of meadows.

DPS-5: Begecka jama

1. *Short description of DPS emphasizing the part of the pilot that is planned to be replicated (keep in mind that the budget for replication is 100.000 euros).*

Constructed Wetland System (CWS) for wastewater treatment

General description of CWS

(Taken from Oral, H.V. and Alagöz, S., 2023. Designing appropriate site determination criteria for installing constructed wetland treatment system based on multi-criteria decision-making analyses. *Environmental Monitoring and Assessment*, *195*(6), p.639)

As one of the NbS examples CWS are regarded as a promising wastewater treatment option. They are engineering methods that are designed and built using natural and regular processes that include active ingredients such as vegetation, soils, plant extracts, algae extracts, fungi, and bacteria that are effective in the wetland to assist with wastewater treatment. This system is preferred in a more controlled environment because it takes advantage of many of the similar progressive processes created in natural wetlands. CWS for wastewater treatment is classified as systems with living aquatic plant species growing in, around, below, or above water in dominant wetlands, shallow lakes, and stream margins. Moreover, a CWS is built on sand, gravel, rock, and other materials on top of a compressed clay layer. It is a system composed of plants that are produced and developed in pools constructed by ensuring that it is filled with equipment that has an easily permeable filtration feature, as well as a type of engineering elements to direct the flow, bringing the fluid waiting time and water level to a proper state.

Compared to other wastewater treatment systems, CWS has an affordable construction and maintenance cost. The system does not require a high energy requirement, does not require a high level of operating expenses, does not have a problem with equipped personnel, and can easily adapt to the environment. Thus, the CWS appears to offer many advantages. In addition to these advantages, CWS exhibits a less frugal 73ilometre compared to other conventional treatment systems. Since the efficiency of the system depends on the changing climatic conditions, the CWS is directly affected.

CWS at DPS 5

The area of the pilot site DPS 5 Begečka Jama is located in the Vojvodina province, Serbia, on the left bank of the Danube River, approximately 20 km west of the city of Novi Sad. It comprises the protected area (Nature Park Begečka Jama) and the surrounding drainage catchment (drainage system Begeč-Gložan).

As the Nature Park Begečka Jama is a dynamic system, which is very susceptible to natural changes, and at the same time, is under strong anthropogenic influence, it is necessary to determine and undertake protection measures that would preserve and improve the existing natural values, and control and reduce the anthropogenic influence into the greatest extent possible.

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For that reason, the decision on the **Protection of the Begečka Jama Nature Park** was adopted in 1999. Many of the threatening factors still remain, only the problems of municipal wastewater treatment were partially solved by designing and implementing the **constructed wetland system for wastewater treatment** from the Gložan settlement.

As mentioned before, constructed wetlands are artificial wetlands that are used for treating organic, inorganic and excess nutrient contaminants in wastewater. Constructed wetlands are engineered systems that use the natural functions of vegetation, soil, and organisms to provide secondary treatment to wastewater. The design of the constructed wetland has to be adjusted according to the type of wastewater to be treated. Similar to natural wetlands, constructed wetlands also act as a biofilter and/or can remove a range of pollutants (such as organic matter, nutrients, pathogens, heavy metals) from the water. Constructed wetlands are designed to remove water pollutants such as suspended solids, organic matter and nutrients (nitrogen and phosphorus). All types of pathogens (i.e., bacteria, viruses, protozoans and helminths) are expected to be removed to some extent in a constructed wetland.

2. *What kind of data did you need to gather before you created, developed and installed your DPS? What kind of hydrological, climatic, environmental, socio-economic data?*

   - **Quantity of wastewater (in our case it depended on the population of the city)**
   - **Quality and type of wastewater (communal, industrial, agricultural)**
   - **Distance of the location from populated places**,
     For practical reasons, primarily cost-saving, the CWS must be located close to settlements,
   - **Distance of the location from recipient,**
     For similar reasons, it is important for CWS to be located near water bodies where the treated wastewater will be discharged.
   - **Land use,**
     The following surface areas were taken into account as areas for CWS implementation: pastures, agricultural areas, forest and semi-natural areas, wetlands, and water bodies.
   - **Elevation,**
     The location of the CWS facilities should be at a lower elevation than the settlements, enabling the gravitational discharge of wastewater.
   - **Presence of embankments,**
     The presence of embankments criterion refers to situations where there is no levee between the settlement and the watercourse, and water can flow by gravity. On the contrary, when there is a levee between the settlement and the watercourse, pumps are required to evacuate wastewater, which increases the construction and operation costs.
   - **Presence of floodplains**
     Floodplains can create conditions for higher flow rates and water velocity through CWS. This reduces the time that water spends in the CWS, which reduces its purification efficiency

3. Describe what goal can be achieved with replication of DPS? What will be the expected outcomes/expected changes and potential benefits of that replication? If possible, please try to list at least one benefit in each of the following categories:

   ☒ water related – **water quantity improvement**
   ☒ environmental – **water status (chemical and ecological) improvement, reaching good ecological potential, increased biodiversity**
   ☒ socio-economic – **creating better and more attractive environment for tourism, sport and recreation**

4. *What criteria should be analyzed when deciding where to replicate your DPS (part of DPS with value about 100.000 euros)? Please try to list everything what is relevant? For instance, try to list at least one criterion for each of the following categories:*

Criteria relevant for northern part of Serbia

By reviewing the literature and considering the characteristics of the studied area, the following six criteria have been selected to evaluate locations in the Vojvodina Province, Serbia:

- **Distance of the location from populated places**,
  For practical reasons, primarily cost-saving, the CWS must be located close to settlements, with a buffer zone of 1000 m around each settlement.
- **Distance of the location from recipient,**
  For similar reasons, it is important for CWS to be located near water bodies where the treated wastewater will be discharged.

- **Land use,**
  The following surface areas were taken into account as 75ilometre75 areas for CWS implementation: pastures, agricultural areas, forest and semi-natural areas, wetlands, and water bodies, while other surface areas were not included in the analysis, such as urban areas.
- **Elevation,**
  The location of the CWS facilities should be at a lower elevation than the settlements, enabling the gravitational discharge of wastewater. In cases where the elevation of the site is higher than the elevation of the settlement, the installation of a pump is necessary, which increases the costs of construction and operation.
- **Presence of embankments,**
  The presence of embankments criterion refers to situations where there is no levee between the settlement and the watercourse, and water can flow by gravity. On the contrary, when there is a levee between the settlement and the watercourse, pumps are required to evacuate wastewater, which increases the construction and operation costs.
- **Presence of floodplains**
  Floodplains can create conditions for higher flow rates and water velocity through CWS. This reduces the time that water spends in the CWS, which reduces its purification efficiency.
- **Slope**
  Although, CWS can be implemented almost everywhere, construction costs can be overwhelmingly high if extensive earthmoving or expensive liners are required. Areas that are reasonably flat and appropriately zoned reduce construction earthworks costs and minimize erosion and drainage works (USEPA 1988).

For more details see the following paper which is result from DALIA project: Antić, S., Benka, P., **Blagojević, B.**, Santrač, N., Salvai, A., Stajić, M., Zemunac, R. And **Bezdan, J**., 2023. Defining Optimal Location of Constructed Wetlands in Vojvodina, Serbia. *Hydrology*, *10*(10), p.192.

Criteria relevant for Northern Greece

By reviewing the literature and considering the characteristics of the studied area, the following criteria have been selected to evaluate locations in the Northern Greece:

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Land Availability Criteria

- **Slope**
  Although, CWS can be implemented almost everywhere, construction costs can be overwhelmingly high if extensive earthmoving or expensive liners are required. Areas that are reasonably flat and appropriately zoned reduce construction earthworks costs and minimize erosion and drainage works (USEPA 1988).
- **Faults**
  Furthermore, safety of facilities against seismic hazards is taken into consideration by forming exclusion zones along both sides of the active faults.
- **Lithology**
  Earthworks cost is strongly related to the lithology, and soils and rocks classification enables sites evaluation according to their use as construction materials (Brodie 1990). The evaluation is performed by classifying geological formations to three categories:

Soils classification for lithology criteria

Lithology	Description	Rank
Sands and gravels with variable amount of clayey silt, alternating with clays	Porous usually loose formations	1
Marls, breccia, bluestones, limestones, trachytes	Moderately consolidated rocks	2
Fissured karstified rocks or zones of tectonized and weathered massive rocks	Hard rocks	3

Natural Resources Protection Criteria

- **Natura 2000 areas**
  Issues regarding the degradation of areas of unique ecological and aesthetic interest call for blockade of sites that are protected by national and international treaties, such as the Natura 2000 network
- **Aquifers vulnerability**
  The siting process should consider groundwater pollution issues. Hydrogeology aspects ensure correct embankment design aiming to protect vulnerable groundwater aquifers and sensitive surface waters. Aquifers are qualitatively evaluated with respect to their potential and their productivity and with matters regarding overlaying conditions.

Aquifers Classification with Respect to Underwater Pollution

Lithology	Description	Rank
Porous usually loose rocks	Extensive aquifers of high productivity	6
	Local aquifers of medium productivity	4
	Local or discontinuous aquifers of low productivity	3
Fissured karstified rocks	Extensive aquifers of high to very high productivity, usually at great depths	7
	Local or discontinuous aquifers of medium to low productivity	5
Porous or fissured rocks semipermeable to practically impermeable	Local occurrences of groundwater in zones of tectonized and weathered massive rocks	2
	Aquifers of no significant productivity even at great depths	1

Socioeconomic Criteria

Criterion maps that represent visual effects, aesthetic considerations, and property assets devaluation are grouped under the term “socioeconomic factors.”

- **Distance of the location from populated places**
  Taking into consideration that politicization of wastewater treatment issues may hamper the construction of public facilities, to reach social consensus, plants should be located 500 m downwind from the residential areas.
- **Distance from transportation networks**

In Greece, land acquisition cost is strongly associated with the nearby existence of public utilities, especially transportation networks. Thus, exclusion zones from the main transportation and railway network should be formed.

Constraints Analysis Synopsis

Constraint	Threshold value
Area grade (%)	< 5%
Distances from faults	> 500 m
Distance from lakes	Exclusion
Natura 2000 network areas	Exclusion
Distance from rivers	> 200 m
Distance from streams	> 80 m
Distance from coastline	> 500 m
Distance from settlements	> 500 m
Distance from national and primary road network	> 300 m
Distance from railway network	> 300 m
Land-use type	Restriction to rural areas

- **Land uses**

  Regarding the land uses, suitability analysis is restricted in agricultural and semi agricultural areas according to the Corine Land Cover geodatabase provided by the EEA. The remaining locations are qualitatively evaluated with respect to the loss of productive activities.

Land use

Land-use type	Rank
Complex cultivation patterns	5
Fruit trees and berry plantations	3
Land principally occupied by agriculture	4
Nonirrigated arable land	2
Olive groves	3
Pastures	1
Permanently irrigated areas	6
Vineyards	4
Rice fields	4

Design Criteria

- **Climatic conditions**

  Should exert influence in the operational capabilities of the natural systems, especially when wetlands are considered as an alternative treatment option. Quantification of the influence of the climatic factor is achieved by estimating mean monthly air temperature Tmm (measured in °C) as a function of the altitude z (measured in meters).
- **Secondary road network**

  The cost of the necessary complementary infrastructures (e.g., roads for the maintenance personnel) is minimized in locations that are as close as possible to the secondary and tertiary road network.
- **Distance of the CWS location from populated places**

  On the other hand, CWS should be located close to the wastewater source to overtake economic constraints derived from the sewage transportation cost.

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- **Distance of the CWS location from the recipient**
  Finally, suitability analysis should ensure proximity to surface water body for effluents discharge.

For more details see the following paper: Anagnostopoulos, K. And Vavatsikos, A., 2012. Site suitability analysis for natural systems for wastewater treatment with spatial fuzzy analytic hierarchy process. *Journal of Water Resources Planning and Management*, *138*(2), pp.125-134.

<u>Criteria relevant for Turkey</u>

List of criteria for the field trip preparation

The land use type (Brodie et al., 1989)
Land slope or topography (EPA, 1993)
The vegetation type (Lombard-Latune et al., 2017)
The appropriate area is located on the floodplain (EPA, 1993)
The archeological developments or sites closure to the area (EPA,1993)
The absence of any endangered and protected plant or animal species in the area to be (EPA, 1993; Spieles, 2022)
The population density per square meter near the area (Hickey et al., 2018)
The distance from human settlements and to other existing wastewater treatment units (Peñacoba et al., 2021; EPA, 2008)
The climatic features (Ellis et al., 2003; Çakmakçı et al., 2017; Verma et al., 2022)
Logistics (Stefanakis, 2020)

For more details see the following paper: Oral, H.V. and Alagöz, S., 2023. Designing appropriate site determination criteria for installing constructed wetland treatment system based on multi-criteria decision-making analyses. *Environmental Monitoring and Assessment*, *195*(6), p.639.

<u>Criteria relevant for Spain</u>
(Oceanic and Mediterranean)

<u>Environmental Factors</u>

- **Temperature**
  Concerning the temperature, the average was representative of the condition at which the METland will perform over time, especially influencing the growth of vegetation and the operational capabilities. For macrophytes (the most common wetland plants) the optimum development temperature was 20 ◦C and the growth range from 16 to 27 ◦C. Temperatures above 30 ◦C and below 10 ◦C produce vegetative detention.
- **Precipitation**
  The maximum precipitation notably influences the system for two reasons: the increase in the inlet water flow due to runoff and the influence of rain on the plants. Therefore, the existence of torrential rains produces a negative effect associated with a higher volume of water to be treated, decreasing the hydraulic retention time and forcing it to enlarge the system area.
- **Solar orientation**
  The sunlight affects the development of vegetation, or more precisely the photosynthesis process. The most suitable orientation in the study area for vegetation was when the slope faces south due to its warmth and luminosity.

<u>Socioeconomic Factors</u>

- **Land use**
  The adequacy for particular land use to build a CWS was taken into account; for example, forests or crops were less suitable than open spaces with little or no vegetation. Furthermore, the economic cost, environmental impact and social appreciation were considered in the classification. The reclassification of

land uses to a quantitative suitability scale of 0 to 10 was performed for each category with a value from 1 (no appropriate) to 10 (very appropriate), summarized in Table below

Land Use *	Value
Forests	1
Permanently irrigated land	3
Rice fields	3
Permanent crops	4
Agro-forestry areas	4
Land principally occupied by agriculture, with significant areas of vegetation	6
Complex cultivation patterns	7
Annual crops associated with permanent crops	7
Non-irrigated arable land	8
Pastures	9
Scrub and/or herbaceous vegetation associations	9
Sparsely vegetated areas	10
Burnt areas	10

* The rest of the categories were included as restrictions.

- **Distance to river beds**
  The distance to the river is a factor that would influence the cost of construction, taking into account that the effluent water of the system would discharge into a river, fulfilling the limits of the current quality regulations.
- **Distance to population centers**
  The distribution of the population in the study areas was analyzed in order to define the distance to the verified inhabited areas. This variable could be decisive in the location of the CW for several reasons. Firstly, the number of people determines the volume of waste water produced. Secondly, the distance from the houses to the CW imposes the length of the conduction which transports the WW. Thirdly, the location of CW close to the population centers could help to change the idea of the sewage treatment plant to an environmentally sustainable garden.
- **Slopes**
  CW should be constructed on low slope surfaces (from 0 to 15%) to get a gradual flow of WW from the inlet to the outlet and avoid overland flow during rainy seasons. In addition, the cost of earthworks and transport of soil is directly related to the slope.

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Factor	Scale	Origin	Description	Reclassification	Normalization Function
Average temperature	1:25,000	AEMET, REDIAM and Provincial Council of Bizkaia	Average temperature interpolated based on the meteorological stations.	Growth range from 16 °C to 27 °C.	Linear monotonically increasing function (a = min., b = max.)
Maximum precipitation	1:25,000	AEMET, REDIAM and Provincial Council of Bizkaia	Maximum precipitation interpolated based on the meteorological stations.	The suitability decrease as higher maximum precipitation value.	Linear monotonically increasing function (a = min., b = max.)
Solar orientation	1:25,000	CNIG Download Center [73]	Land classification regarding the solar orientation based on the DEM.	The suitability increase in the south-oriented zones.	Symmetrical sigmoidal function (a = 45, b = 135, c = 225, d = 270)
Land use	1:100,000	CORINE Land Cover Project of IGN 2012	Reclassification of the land use database, according to high, medium o low level of suitability.	Land uses with special environmental or economic value are less suitable for the system.	Linear monotonically increasing function (a = 0, b = 10)
Distance to river beds	1:25,000	Water network database [74]	Distance to each river of the national water network in Spain.	Highest suitability values for places closer to the river systems.	Linear monotonically decreasing function (c = 25, d = max.)
Distance to population centers	1:25,000	INE, IGN, SIOSE [73]	Distance to inhabited areas considering from one household to cities. Avoiding non-residential buildings.	Areas closer to inhabited buildings are more suitable for construction.	Linear monotonically decreasing function (c = 25, d = max.)
Slope	1:25,000	CNIG Download Center [73]	Reclassification based on the percentage of slope suitable for the system.	Slopes between 0 and 15% have a linear suitability decrement.	Linear monotonically decreasing function (c = 0, d = 15)

AEMET: Spanish Agency of Meteorology; CNIG: National Center of Geographical Information; IGN: National Geographic Institute; INE: National Statistics Institute; MITECO: Ministry of Ecological Transition; REDIAM: Environmental Information Network of Andalucía.

Conclusion is that the most influential factors are: **(i) land use, (ii) distance to population centers, and (iii) distance to river beds.** Interestingly, the model could predict best suitable locations by reducing the number of analyzed factors to just such three key factors (**responsible for 78% of the output variance**).

For more details see the following paper: Peñacoba-Antona, L., Gómez-Delgado, M. And Esteve-Núñez, A., 2021. Multi-criteria evaluation and sensitivity analysis for the optimal location of constructed wetlands (METland) at oceanic and Mediterranean Areas. *International Journal of Environmental Research and Public Health*, *18*(10), p. 5415.

5. *How would you measure previously listed criteria (define what type of attributes: natural, proxy or constructed)?*

- Distance of the location from populated places – in meters (natural attribute)
- Distance of the location from recipient – in meters (natural attribute)
- Land use – by using Corine (constructed attribute)
- Elevation – in meters above sea level (natural attribute)
- Presence of embankments – yes or no (constructed attribute)
- Presence of floodplains – yes or no (constructed attribute)
- Slope – in % (natural attribute)

6. *To your best knowledge, is it easy or complicated to obtain data for previously listed criteria and attributes for other associated regions?*

- Distance of the location from populated places – easy
- Distance of the location from recipient – easy
- Land use – easy
- Elevation – easy
- Presence of embankments – easy
- Presence of floodplains – easy

- Slope – easy

7. *What are the limitations where your DPS may be replicated?*

   For CWS replication limitations are settlements with less the 5000 citizens, locations where the size of the empty lot exceeds 2 ha.

8. *Please suggest specific locations (minimum 5) where your pilot may be replicated (for each location, explain why you think it is suitable to be a replication location in more detail as possible; what are the conditions that make it perfect for your pilot; do you have data for that location and which one (for example climate, natural conditions, socio-economic data, etc.).*

   CWS can be replicated in almost all European regions. It can be seen in literature that CWS exist in almost all parts of the Europe. Here we can suggest following locations for CWS replication: Bijeljina municipality (Bosnia and Herzegovina), City of Banja Luka (Bosnia and Herzegovina), Brčko District (Bosnia and Herzegovina), flat part of Slovenia, flat part of Austria.

9. *Now, use objectives/criteria from question 4 to guide the search for locations (associated regions). Focus first on each objective/criterion one at a time and ask yourselves, what are some locations that might measure up well in terms of this objective? Then one considers sets of more than one objective and asks an analogous question. For instance, ask yourself which locations can be good for replications according to water quality criterion? Then, which locations can be good for replications according to hydrological criterion? Etc.*

   We answered question 8, according to the criteria described in questions 4, 5.

10. *For listed locations, try to provide estimation if it is possible to obtain data related to previously listed criteria/objectives.*

    It is easy to obtain all data for previously listed criteria.

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DPS-6: Sturgeon migration by-pass

1. *Short description of DPS emphasizing the part of the pilot that is planned to be replicated (keep in mind that the budget for replication is 100.000 euros.*

   DPS6 aims to tackle the issue of Danube connectivity with regards to migration routes of sturgeon specimens, via ultrasonic tagging of sturgeon specimens, in order to by-pass the Iron Gates hydropower plants. The innovative solution is patent pending, and is tailored specifically for physical obstacles. The other components of the pilot, that consist of sturgeon monitoring by using fixed systems and mobile monitoring by boat, are designed to be attuned to the specific tags used for the specimens.
   The specific conditions that would have to be met and the available budget **does not allow the replication of major components** of DPS-6 actions.

2. *What kind of data you needed to gather before you created, developed and installed your DPS? What kind of hydrological, climatic, environmental, socio-economic data?*

   The by-pass solution for the ultrasonic tagged sturgeon specimens for DPS6 is in design, patent and development stage, it will be implemented during the DALIA project. The necessary data is represented by the specific conditions of the Iron Gates I and II hydropower plants, hydro-morphological data like water depth, water velocity, and migration 82 kilometre data for the sturgeon species in the Lower Danube.

3. *Describe what goal can be achieved with replication of DPS? What will be the expected outcomes/expected changes and potential benefits of that replication? If possible, please try to list at least one benefit in each of the following categories:*
   - ➔ *socio-economic*
   - ➔ *environmental*
   - ➔ *water related*

   See answer no.1

4. *What criteria should be analyzed when deciding where to replicate your DPS (part of DPS with value about 100.000 euros)? Please try to list everything what is relevant? For instance, try to list at least one criterion for each of the following categories:*
   - ➔ hydrological criteria (water quantity, type of river: lowland, mountain river, etc.):
   - ➔ climate criteria
   - ➔ soil criteria
   - ➔ geomorphologic criteria
   - ➔ vegetation criteria
   - ➔ water quality
   - ➔ socio-economic criteria
   - ➔ tourism: Wege, Plakate
   - ➔ recreational
   - ➔ wildlife, etc

   See answer no.1

5. *How would you measure previously listed criteria (define what type of attributes: natural, proxy or constructed)?*

   Not applicable

6. *To your best knowledge, is it easy or complicated to obtain data for previously listed criteria and attributes for other associated regions?*

   Not applicable

7. *What are the limitations where your DPS may be replicated? For example, for pilot-constructed wetland replication criteria are settlements with less the 5000 citizens, locations where exist empty lot of size more than 2 ha.*

   Considering that the DPS6 addresses two specific, localized components: the Iron Gates I and II hydropower stations and ultrasonic tagged sturgeon specimens in the Lower Danube, these conditions cannot be found in other areas for replication.

8. *Please suggest specific locations (minimum 5) where your pilot may be replicated (for each location, explain why you think it is suitable to be a replication location in more detail as possible; what are the conditions that make it perfect for your pilot; do you have data for that location and which one (for example climate, natural conditions, socio-economic data, etc.).*

   See answer no.7.

9. *Now, use objectives/criteria from question 4 to guide the search for locations (associated regions). Focus first on each objective/criterion one at a time and ask yourselves, what are some locations that might measure up well in terms of this objective? Then one considers sets of more than one objective and asks an analogous question. For instance, ask yourself which locations can be good for replications according to water quality criterion? Then, which locations can be good for replications according to hydrological criterion? Etc.*

   Not applicable.

10. *For listed locations, try to provide estimation is it possible to obtain data related to previously listed criteria/objectives.*

    Not applicable

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DPS-7: Danube Delta Monitoring

1. *Short description of DPS emphasizing the part of the pilot that is planned to be replicated (keep in mind that the budget for replication is 100.000 euros).*

   In the DPS 7, the study area is Sulina Branch. Since this branch is an important navigation channel, increased shipping traffic affects the water and sediment quality. The banks, generally protected by stones, gravel or groynes, alternate with natural areas that erode during high water or due to waves caused by ships. A continuous process of erosional sand deposition occurs due to changes in water currents. All the polluting substances brought to Sulina city, from the upstream area, are due both to the discharges of polluting materials, as well as to the use of ships and boats, representing the only means of transport in the area, or to the transit of marine ships. The contaminant transport out of the catchment area into the marine systems is of particular importance when dealing with sediments.

   Sediment related data are a prerequisite for appropriate planning and the evaluation of any sediment management measure. The improvement of the monitoring systems concerns the high temporal resolution (e.g. 15 min) measurements of suspended sediment concentration (SSC) at one point in the cross-section using optical or acoustic backscatter sensors. To measure the temporal variability of the suspended sediment transport to the Black Sea, in DPS7, an optical sensor is installed which continuously records the turbidity at one point in the cross section (near the bank). The is equipped as follows: 1) radar level sensor for water; 2) air temperature sensor with cable and solar protection; 3) Hach Solitax turbidity and suspended solids sensors (unit of measure **automated monitoring station** mg/l); 4) salinity and water temperature sensors; 5) photovoltaic panel (minimum 60 W); 6) datalogger Net Dl 500 with analogous module, with built-in GPRS modem.

   Innovative elements of DPS7:
   1) Dynamic control of sediment transport (using continuous monitoring system)
   2) Stakeholder decision support related to the water and sediment quality

   UDJG will use the data obtained during the periods of seasonal monitoring of sediment and water quality on the Sulina branch, as well as from the monitoring station that will be installed by NIHWM, prediction models will be developed regarding both the water quality matrix, the concentrations of suspended sediments, as well as the presence and accumulation of different types of sediments. These models will then be able to be replicated in any area along the Danube or other rivers.
   Also, by developing forecast models based on time series data of water and sediment quality through using of ARIMA, decision-makers will be able to make management decisions regarding water and sediment quality.
   By applying these models, the aim is to create an integrated system in the medium and long term, with the possibility of expansion over time, including the main riparian countries, as well as integrated observation for all hydrographic basins. All this will allow replication in any area without special costs and with a special impact in making decisions that can lead to improvements in the quality of water courses.

2. *What kind of data you needed to gather before you created, developed and installed your DPS? What kind of hydrological, climatic, environmental, socio-economic data?*

   Hydrological indicators: time-series data for surface water levels and discharges and its historical values, time-series data for turbidity, water temperature, salinity, cross section profile, historical floodplain
   These are needed in order to caracterize the study area and to design the automated monitoring station.

   In order to develop the proposed prediction models, models related both to the water quality matrix, to the concentrations of suspended sediments, and to the presence and accumulation of different types of sediments, it will be necessary to periodically measure the physico-chemical and biological parameters to establish the quality the water course. We will carry out seasonal monitoring and assessment of water and sediment quality in the Sulina branch, sector using physico-chemical parameters, i.e. pH, DO, BOD5, COD, N-NH4+, N-NO3-, N-NO2-, N-total. , P-total, SO42-, CI-, Fe-total, Zn2+, Cr-total; Cd2+, Ni2+ etc. Based on these parameters, the water quality index (WQI), the potential ecological risk index (RI) will be calculated. We will assess the influence of anthropogenic activities on the level of heavy metal contamination in surface sediments using specific pollution indices, i.e. geo-accumulation index (Igeo), contamination factor (CF) or pollution load index (PLI).

Socio-economic indicators: navigation (yes/no), dreging area (yes/no), sources of pollution, acces way to the study area, hydrometer worker for hydrometrical survey (yes/no),
Climatic conditions: sunny days (statistic), wind (average value)
These are needed in order to highlight the effect of human activites in the current state and the possibility to survey and calibrate the sensors.

3. *Describe what goal can be achieved with replication of DPS? What will be the expected outcomes/expected changes and potential benefits of that replication? If possible, please try to list at least one benefit in each of the following categories:*
   - ➔ **socio-economic:** growing acceptance between different water management goals (navigation, fishing, sediment transport, coastal erosion); the use of the machine learning technique that can really reduce the costs necessary to monitor some chemical parameters for which the costs are high.
   - ➔ **environmental:** sediment quantity and quality monitoring improvement, marine water status improvement;
   - ➔ **water related:** effective and integrated water sediment management by involving stakeholders in the decision-making process; provision of information that will be used by decision-makers to improve the quality of the Danube ecosystem and better management of situations in which accidental pollution may occur.

4. *What criteria should be analyzed when deciding where to replicate your DPS (part of DPS with value about 100.000 euros)? Please try to list everything what is relevant? For instance, try to list at least one criterion for each of the following categories:*
   - ➔ hydrological criteria: water levels and discharges, type of river: large river
   - ➔ climate criteria: sunny days, wind
   - ➔ soil criteria: nature of the river bed
   - ➔ geomorphologic criteria: cross section profile, vegetation and nature of banks
   - ➔ vegetation criteria: acces on the banks, to the automated monitoring station
   - ➔ water quality: concentration of chemical compounds in sediments
   - ➔ socio-economic criteria: human activities (e.g. navigation), source of pollution, existence of bridges in study area
   - ➔ tourism: access to the study area for people (on shore and water) and possibility of fencing the automated station in order to assure the equipment's protection
   - ➔ recreational: access of boats in the area that may affect the quality of sensor data in order to assure the measurement quality and equipment's protection
   - ➔ wildlife: existence of wild animals in the area
   - ➔ remote communication: existence of GPRS signal

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5. *How would you measure previously listed criteria (define what type of attributes: natural, proxy or constructed)?*

- The area where the replication will be done should be relatively close to the area where the DSP is located where the initial studies were carried out in order to reduce costs, and the environmental conditions should be relatively similar;
- The purchase and installation in the site where the replication of a fixed monitoring station will be made, even if it will initially involve a high financial effort, will lead to long-term savings as a result of the reduction of personnel and travel costs, and the recorded data of the station will be transmitted in real time and will be processed with the help of IT models made in DSP.

6. *To your best knowledge, is it easy or complicated to obtain data for previously listed criteria and attributes for other associated regions?*

   Hydrological criteria – moderately difficult
   Socio-economic indicators: easy
   Climatic conditions: easy

7. *What are the limitations where your DPS may be replicated? For example, for pilot-constructed wetland replication criteria are settlements with less the 5000 citizens, locations where an empty lot of size more than 2 ha exists.*

   In principle there are no limitations, but it is better to have a land access road to the automated monitoring station and a hydrometer worker to assure calibration of sensors. In Romania, before installing the automatic station, consent for installation or use of land is required from those who manage the land. It could be the same situation in other country.
   Also, in the first year, researchers should be allowed access to take samples to establish the state of the ecosystem and based on other chemical parameters than those monitored by the fixed station, parameters that will be calculated later only on the basis of the data transmitted by the fixed station by calculation and to validate the method in the respective area.

8. *Please suggest specific locations (minimum 5) where your pilot may be replicated (for each location, explain why you think it is suitable to be a replication location in more detail as possible; what are the conditions that make it perfect for your pilot; do you have data for that location and which one (for example climate, natural conditions, socio-economic data, etc.).*

   Regions in which sediment management needs to be reconsidered, because the sediment transport decreased influence the coastal erosion, and where polluted sediments affect the marine environment
   Croatia: Drava River (last kilometres before Danube confluence);
   Sava River (near Slavonski Brod)
   Ukraine: Bastroe
   Slovenia: Sava River
   Moldova: Prut River (transboundary area Romanian-Moldova)
   Bosnia-Herzegovina: Sava River (Samac harbour)

9. *Now, use objectives/criteria from question 4 to guide the search for locations (associated regions). Focus first on each objective/criterion one at a time and ask yourselves, what are some locations that might measure up well in terms of this objective? Then one considers sets of more than one objective and asks an analogous question. For instance, ask yourself which locations can be good for replications according to water quality criterion? Then, which locations can be good for replications according to hydrological criterion? Etc.*

We answered question 8, according to the criteria described in question 4.

10. *For listed locations, try to provide estimation is it possible to obtain data related to previously listed criteria/objectives.*

From regional water authorities, ICPDR, River Basin Management Plan, hydrological institutions: data on existing hydrological structures, ministry of environment, water, ministry of navigation, environmental agencies, local authorities (city halls, etc.).

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DPS-8: Tackling Plastic Waste in the Bodrog Floodplain

1. *Short description of DPS emphasizing the part of the pilot that is planned to be replicated (keep in mind that the budget for replication is 100.000 euros).*

   On DPS No.8, we are engaged in extensive monitoring, habitat restoration, and environmental education activities along the Bodrog River with regards to plastic pollution. This river is a significant tributary of the Tisza River, which is the longest Danube tributary. The Bodrog River is frequently subjected to "plastic flood" incidents, during which the inflow of plastic waste can reach a staggering rate of over 200 plastic bottles per minute. The source of this pollution can be traced back to the Transcarpathian region of war-torn Ukraine, where the challenges of waste management are significant, and recycling infrastructure is either struggling or non-existent. Conservative estimates suggest that the floodplains of the Bodrog currently harbour approximately 0.89 metric tons of plastic and other pollutants that have accumulated along its shores. Our activities are concentrated on a river stretch exceeding 50 kilometers and are grounded in the scientific, environmental, and educational framework developed by the Plastic Cup Society[1]. Research data indicate that a staggering 80% of marine litter originates from inland sources and is transported to the sea via rivers[2]. As a lighthouse partner within DALIA, the Plastic Cup Society is committed to contributing to the European Union's Mission to Restore our Ocean and Waters by 2030. Our primary focus involves actively monitoring and targeting riverine litter accumulations – precursors of marine litter – in the Bodrog River and its floodplain. Our educational initiatives are designed to play a significant role in preventing future instances of plastic pollution, often referred to as 'plastic floods,' within the Bodrog River's water catchment area. By undertaking these comprehensive efforts, we aim to protect the environment and ensure the sustainable health of this vital river ecosystem. DPS8 has special significance as parts of it belong to the NATURA 2000 Network, and the Tokaj region is registered as part of the world's cultural heritage by UNESCO.

   We are ready to share our 10+ years know-how about plastic pollution of rivers in open access approach with regards:

   - know-how and protocols about organizing river monitoring, cleanups and awareness raising, among others, based on our know-how and support monitoring and cleanups have been successfully organized in Slovakia, Ukraine, Romania, Serbia and Bulgaria (see for example our handguide as protocol: https://www.interregdanube.eu/uploads/media/approved_project_output/0001/56/4fb08d491141573d5aecbea014f841deaa6cb28c7.pdf)
   - technical designs for waste collection boats and other devices for river (see later)

   Ideally, our transferable know-how would be a mixture of protocols for citizen science and involvement (clean-ups and monitoring) and technical designs for boats, GPS bottles and river litter skimmer, etc. (see later).

2. *What kind of data you needed to gather before you created, developed and installed your DPS? What kind of hydrological, climatic, environmental, socio-economic data?*

   Research and monitoring activities on DPS8 included the survey on the location, quantity, composition and distribution of riverine litter accumulations. A citizen science program was launched by the Plastic Cup Society to survey the floodplains of the entire Tisza River and some tributaries, including the Bodrog.

[1] remark: DALIA partner THU was recently renamed as Plastic Cup Society

[2] Meijer, L. J., Van Emmerik, T., Van Der Ent, R., Schmidt, C., & Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. Science Advances, 7(18), eaaz5803.

Volunteers reported coastal riverine litter accumulations using a smartphone app connected to an online river pollution map.

In 5+ years, after covering 4500 kms on foot, volunteers from 5 countries recorded and registered 3216 coastal riverine litter accumulations in the Tisza River Basin. The most polluted waterway in the TRB was the main river Tisza with 2667 polluted areas. Monitoring activities included the entire Bodrog river (by Slovakian and Hungarian volunteers) as well as the affluent river Latorica (by Ukrainian volunteers). Tributary rivers Somes and Bodrog were also heavily affected by transnational riverine litter pollution.

Results suggest that alluvial forests and artificial water engineering facilities such as hydropower plants, have considerable waste retention capacity. The online pollution map shows that rivers not only transport riverine litter towards the sea, but also become more polluted themselves until proper preventive and reactive actions are taken.

Results of this activity were first reported in Vienna, 2023 on the World's Large Rivers conference[3]. **In DALIA we suggest that this affordable method can be replicated on a small scale prior to cleanup efforts in the pilot area.**

For the online pollution map visit the beta version online[4]. The map will be further developed within the DALIA project to expand it to the whole Danube Basin and also include river saver location (i.e. places that are best practices and tackle plastic pollution, such as shores adopted by local schools, river saver restaurants, etc. – protocols for these applications are under development by Plastic Cup and will be available and open for anyone through the map).

Geospatial distribution of coastal riverine litter accumulations in the Bodrog River floodplains. Source: the Clean Tisza Map www.tisztatiszaterkep.hu

A **personal survey** of these extensive floodplain forests – especially during wintertime when the vegetation does not cover plastic deposits – does reveal plastic accumulations accurately. However, there are several

[3] A.D.Molnár et al. (2023) Monitoring coastal riverine litter accumulations in the Tisza River Basin, In Proceedings of the 40th IAHR World Congress, 21–25 August 2023, Vienna, Austria

[4] External link for the Clean Tisza Map: www.tisztatiszaterkep.hu

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disadvantages to the method. Among them is the obvious need for repetition: in order to keep the database up to date, the survey has to be repeated on a regular basis. One can agree that this is not necessarily the best use of resources. For this reason, Plastic Cup applied other data collection protocols, with GPS tagging and remote sensing methods included. Thanks to continuous development work, the **GPS tagging of floating plastic bottles** has been developed into a robust and affordable method to monitor plastic flood events in real-time. Plastic Cup has set additional developmental objectives for the upcoming prototype version, slated for deployment during the DALIA pilot implementation. Further trials will be conducted to provide valuable input for efforts and enhance our understanding of plastic pollution dynamics in the Bodrog River, particularly regarding the formation of floating and coastal riverine litter accumulations.

The third advancement in research activities in DPS8 is the application of **remote sensing**. Floating macroplastic accumulations are formed in several stages during the migration of the riverine litter from its source to the marine environments. Plastic Cup's preliminary data shows that floating riverine litter accumulations that are NOT covered by vegetation are detectable from the air and from space alike. Earth observation satellites equipped with medium- and high-resolution multispectral sensors have undergone major technological developments. Remote sensing of the formation of floating waste accumulations was tested using Sentinel-2 and PLANETSCOPE satellite imagery and machine learning. An automated evaluator for waste monitoring and change detection was developed as part of the research[5]. The program provides an easy and robust solution to configure territories for continuous observation. The application downloads satellite images from the mentioned sources on a daily basis (given that a new image is available for the selected area) and compares the amount of waste covered surface to previous images.

In DALIA, further trials will be conducted to provide valuable input for modeling efforts and enhance our understanding of plastic pollution dynamics in the Bodrog River, particularly regarding the early detection and warning system related to forthcoming plastic floods. For this, ICPDR has offered professional help from IT experts. In conclusion, all three methods—**pollution monitoring through a smartphone application, tracking plastic bottles with GPS tags, and employing remote sensing**—can be readily implemented in associated regions for the purposes of replication, adaptation, and optimization.

Regarding replication of our DPS to other regions, preliminary mapping and confirmation of plastic pollution are enough with further research during the implementation by GPS bottles and remote sensing in cooperation with the regional implementing body. A few data (and maps) will be needed about the river, too – how the shores look like, how accessible they are, etc. (google maps is ok), plus basic general info about the river section targeted for replication.

3. *Describe what goal can be achieved with replication of DPS? What will be the expected outcomes/expected changes and potential benefits of that replication? If possible, please try to list at least one benefit in each of the following categories:*

The **socio-economic** impact of plastic pollution in marine environments has long been recognized, particularly due to its detrimental effects on industries such as fishing and tourism. According to a 2019 report, marine litter caused a loss of €300 million to the EU economy, including entanglement in floating plastics and lost revenues in the fishing industry. In response to this growing environmental challenge, beach and ocean cleanup activities have become more prevalent in recent years. However, rivers have received significantly less attention, even though the **environmental** services provided by rivers are vital (fresh water, hydropower, fishing, shipping, tourism, etc.). Fortunately, the situation has recently changed, and river cleanup operations have emerged worldwide. Based on the criteria outlined in the Transnational River Cleanup Handguide[6]

[5] Magyar, D., Cserép, M., Vincellér, Z., & Molnár, A. D. (2023). Waste Detection and Change Analysis based on Multispectral Satellite Imagery. *arXiv preprint arXiv:2303.14521*.
[6] A Danube Interreg output: Aquatic Plastic

protocols can be categorized into two distinct types: community river cleanups (CRUs) and professional river cleanups (PRUs). Experience has shown that community efforts, such as CRUs, are effective in targeting coastal and stranded riverine litter accumulations. However, when dealing with flowing and floating riverine litter accumulations, trained crews, accredited tools and equipment, and specific action protocols are required, making PRUs essential in these cases. Regardless of the applied methodology, each cleanup activity **improves water quality** in the area instantly and prevents further pollution in the downstream areas. The same applies to the replication of educational activities (River Litter Lab, RiverSaver protocols) carried out on DPS8 which have a direct effect on the source of pollution.

The goal we can expect as replication:

- Raising awareness and teach local people to feel responsible for the river and arm them with methods to prevent and cleanup pollution. The replication would be not just (for example) a simple cleanup but establishment of RiverSaver locations (for example a shore adopted by local school, or a river saver restaurant qualified, etc.) which can be in the future act as focal point and catalyzer for further citizen/community actions, and also network point for us with putting it on the Clean Tisza map.
- Having technical equipment to tackle the pollution (boat, river litter skimmer, GPS bottle, etc.) that are in good hands and used in the future supporting community actions with professional tools.

4. *What criteria should be analyzed when deciding where to replicate your DPS (part of DPS with value about 100.000 euros)? Please try to list everything what is relevant? For instance, try to list at least one criterion for each of the following categories:*

☒ **hydrological criteria (water quantity, type of river: lowland, mountain river, etc.):**
For adaptation and replication purposes of activities implemented on DPS8 we should seek for upstream areas where water and waste management face fundamental problems (lack of financing, illegal deposition, malfunctions, poor infrastructure). In order to implement monitoring, cleanups and educational activities we are looking for mountainous areas where running waters are periodically capable of carrying away mistreated communal and industrial wastes. These regions can be defined as leakage zones or hotspot areas where most of the transnational riverine litter pollution can be traced back.

☒ **climate criteria**
In the Danube River Basin, we can describe the potential areas as moderate, continental climate zones, where precipitation is higher in certain part of the year and as a result, the flood events are periodic in their nature. These are the areas where illegally deposited waste can be found on the riverbanks, and as soon as the water level rises (floods), riverine litter is formed.

☒ **soil and geomorphologic criteria**
For adaptation of educational and cleanup activities, there are no specific requirements considering the geomorphology of the given area. However, community river cleanups (CRCs) and professional river cleanups (PRCs) equally require high flow velocity. It is very important to note that the increased current speed is NOT necessary throughout the year. It is well enough if there are 2-3 flood events annually, when water levels and average flow and discharge increases. These periodic changes play an important role in the mobilization of mistreated communal waste and as a result in the formation of riverine litter accumulations.

☒ **vegetation criteria**

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Experience shows that dense vegetation along the shorelines favors the formation of coastal riverine litter accumulations. Fallen trees and organic debris increase the chance of the formation of floating riverine litter accumulations.

☒ **water quality**

The International Commission for the Protection of the Danube River (ICPDR) considers riverine litter and plastics as emergent pollutants directly and indirectly jeopardizing the water quality. DALIA activities improving this should be implemented in areas where at least one of the following conditions apply:

- Illegal dumping, mistreated waste deposits along shorelines,
- Floating riverine litter on the surface of the water bodies,
- Plastic flood events associated to high waters,
- Deposited riverine litter accumulations along the shorelines,
- Poor waste management practices,
- Poor waste recycling capacities.

☒ **socio-economic criteria**

The socio-economic importance of rivers is beyond question, for thousands of years we relied on them as a source for water and food, for irrigation, recreation, and recently hydropower generation purposes, amongst many other uses. Consequently, the true costs of the increasing amounts of mistreated domestic and industrial waste present in natural water bodies are hard to estimate. Riverine litter affects different industries (fishing, shipping, tourism) causing losses often referred to as economic costs. The direct economic costs related to cleanup interventions on European beaches alone are staggering. A 2010 study revealed that for cleaning up each kilometre of the UK coastline, an average amount of €7000-7300 was paid, annually. To decrease the negative impacts of marine litter, the EU funds beach cleanup operations with €630.000.000 – on a yearly basis. Other costs include ecosystem deterioration, loss of species and habitats causing a loss in environmental values or ecosystem services.

All river cleanup interventions leave a carbon footprint, but they cause other forms of environmental stress (damage to native vegetation, noise pollution, visual pollution, dust, etc.) affecting the natural ecosystem of running freshwater habitats as well as local communities. The negative side-effects of any river cleanup action must not be underestimated, and they have to be exceeded by the positive impacts a given technology and protocol can achieve. Thermoplastic polymers, or most widely known as 'plastics' are made primarily from crude oil. Additives used to manufacture plastics are produced by the petrochemical industry too, so the general notion that plastic pollution can be considered as a special form of oil spills, is not unfounded. Taking how closely the petrochemical industry is interconnected with plastic production it might not come as a surprise that the current and widely accepted methods used to skim & contain an oil spill are very similar to those applications used to halt and contain riverine litter. The booms and skimmers effectively isolate oil and floating plastics alike. However, when taking environmental concerns into consideration, traditional methods have their disadvantages: they collect everything that floats on the surface.

Mixing riverine litter with organic debris (e.g. driftwood) during collection increases the costs (e.g. human labor, carbon footprint) of the intervention and reduces the expected benefits (e.g. recycling) greatly. By relying mostly on renewable technologies and enabling selection to start right at water level, the high TRL level HYDRA solution has multiple advantages. HYDR runs mainly on renewable energy sources and causes minimal impact to the environment (reduced if not zero noise, air and water pollution). HYDR does not require basic landscaping works, does not alter or damage the living conditions in coastal and underwater habitats. HYDR has the potential for maximum adaptability and replicability.

☒ **tourism: recreational, wildlife, etc**

The list of economic sectors and industries affected by the marine litter includes agriculture; aquaculture; fisheries; commercial shipping and recreational boating; coastal municipalities; coastal tourism sector and the emergency rescue services. In case of riverine litter, water authorities and water engineering companies (e.g. hydropower generation) are also affected adversely. In general, those benefiting from the implementation of river cleanup interventions include riverside communities on the lower sections of the given waterways; the wildlife of the running waterway as well as its floodplains; and affected industries. In particular, the deployment of sustainable river cleanup solutions such as the HYDRA riverine litter skimmer, is beneficial primarily for the operators of artificial water engineering structures (hydropower plants, dams) making the separation, collection and recycling/deposition of riverine litter cost effective and environmentally friendly.

5. *How would you measure previously listed criteria (define what type of attributes: natural, proxy or constructed)?*

We could measure the amount of plastic in the floodplain and on the river by estimation or measurement, the collected waste and cleaned area by exact measures and the involved stakeholders (number, type). These are the most important ones.

6. *To your best knowledge, is it easy or complicated to obtain data for previously listed criteria and attributes for other associated regions?*

Experience shows that in non-EU countries of the Danube River Basin it is very difficult to obtain official data considering water quality, pollution, waste management and water management issues. For this reason in DALIA, we propose solutions that are easy to implement, reliable and robust, cost effective and do not require special permits (smartphone application, GPS tagging, remote sensing). The application of these solutions depends on a reliable partner and the availability of well tested methods and protocols, provided by DPS8.

7. *What are the limitations where your DPS may be replicated? For example, for pilot-constructed wetland replication criteria are settlements with less the 5000 citizens, or locations where an empty lot sized more than 2 ha exists.*

For monitoring activities, the limitations arise when not the entire shoreline of the site is available for personal survey (private property, strictly protected areas, hunting grounds, constructions sites, etc.). In this case the detection and reporting of coastal riverine litter accumulations can be problematic, and one needs to find other solutions (access from the water, ask for permissions, etc.). But for pilot implementation is not really necessary to track and monitor a long river section just the part targeted by the intervention.

The other jeopardizing factor can be the difficult terrain, making the personal survey difficult to carry out. In this scenario the alternate monitoring methods – GPS tagging, remote sensing – have a special significance. For river cleanup activities the limitation is the morphological structure of the riverbed (are there appropriate intervention points) and the road access to the intervention point. For educational activities the network to local NGOs and educational institutions (primary and secondary schools, schoolchildren and teachers) can be of critical importance.

8. *Please suggest specific locations (minimum 5) where your pilot may be replicated (for each location, explain why you think it is suitable to be a replication location in more detail as possible; what are the conditions that*

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make it perfect for your pilot; do you have data for that location and which one (for example climate, natural conditions, socio-economic data, etc.).

- Bosnia Herzegovina, Visegrad, Drina River – this link is self-explanatory
  - https://www.euronews.com/green/2023/06/04/we-will-die-before-the-drina-is-clean-bosnia-villagers-hope-for-a-solution-to-polluted-riv
- Ukraine, Transcarpathia, Black and White Tisza River
- Ukraine, Vinograd, Borzhava River
- Ukraine, Uzhhorog – Munkachevo, Latorica River
- Most western part of Ukraine, Transcarpathia is the main source of plastic pollution in the Tisza River basin. See more here:
  - https://streamnext.hu/magazin/?apiKey=ad5d58f5-0177-4245-98de-5b00a74752ef#/hir/724-tonnes-of-waste-collected-and-processed-thanks-to-the-call-action-programme
  - https://streamnext.hu/magazin/?apiKey=ad5d58f5-0177-4245-98de-5b00a74752ef#/hir/an-environmental-documentary
- For both Bosnia and Ukraine, we have data about plastic pollution.

9. *Now, use objectives/criteria from question 4 to guide the search for locations (associated regions). Focus first on each objective/criterion one at a time and ask yourselves, what are some locations that might measure up well in terms of this objective? Then one considers sets of more than one objective and asks an analogous question. For instance, ask yourself which locations can be good for replications according to water quality criterion? Then, which locations can be good for replications according to hydrological criterion? Etc.*

   Plastic polluted rivers, more details already listed above at previous questions.

10. *For listed locations, try to provide estimation is it possible to obtain data related to previously listed criteria/objectives.*

    We have data on plastic pollution, the general needed information about the river affected can be found on internet and google maps.

More details about the technologies that are offered for replication:

DESCRIPTION OF FAST RESPONSE RIVER CLEANUP WORKBOATS
The special characteristics of riverine plastic pollution in the Tisza-basin make it difficult to apply internationally acclaimed river cleanup devices (e.g. Interceptor, Collectix, etc.) and other best-practice tools one on one. Unlike the situation of Asian rivers where pollution is a more or less round-the-clock phenomena, macroplastic pollution along the Tisza and its tributaries is coming in waves, usually associated with quick floods. High waters, strong and quick currents and the high amount of organic waste – most of all large pieces of driftwood – makes collection of inorganic (plastic, metal, glass, etc.) waste extremely difficult. Water Authorities in Hungary have unique references in working under these difficult conditions and collecting waste from larger rivers. These activities, however, are yet to be extended to smaller tributaries as well. The pollution events on small rivers are even more sporadic but their contribution to the overall pollution cannot be underestimated.

Community river cleanups
Professional river cleanups at HEPPs and floodplain forests
Innovative river cleanup interventions, manned workboats

In general, professional river cleanups (PRCs) are implemented by trained, officially employed, and experienced personnel; carried out throughout the year, often in difficult conditions; lead to the removal of a considerable amount of riverine litter; and involve the application of heavy duty machinery often developed for this very purpose. Of all forms of riverine litter, the most difficult to collect is the riverine litter that is on the move (see above 'Motile stage'). The Netherlands based NGO, Ocean Cleanup (OCU) is leading the way with its meticulously developed series of riverine litter collecting **workboats**, called 'Interceptors'[7]. OCU have set up sophisticated workboats where they are most needed: on various rivers in Asia where plastic pollution is an around-the-clock phenomenon. The special characteristics of riverine plastic pollution in the Danube River Basin make it difficult to apply internationally acclaimed river cleanup devices (e.g. Interceptor) one on one. Unlike the situation of Asian rivers, macroplastic pollution along the Danube and its tributaries is coming in waves, usually associated with quick floods. Strong currents and the high amount of organic waste – most of all large pieces of driftwood – makes collection of inorganic (plastic, metal, glass, etc.) waste extremely difficult. Water Authorities in Hungary have unique references in working under these difficult conditions (flow velocity up to 3m/sec). The "**Floating Machine Chain"** is a combined application of heavy machinery and **modified barges.** It has proven to be especially successful on the fastly running and dangerous waters of the Somes and Upper-Tisza rivers[8]. The temporary system of refurbished workboats, operated by FETIVIZIG (Upper Tisza Valley Water Management Directorate) have managed more than a thousand cubic meters of riverine litter and about 900 tons of organic waste (mainly driftwood) since their first operation back in 2020[9]. The **PETII** is a lightweight fast-response riverine litter collector boat[10] developed by the Plastic Cup with the help of private boat designers. When in operation the boat is steered using renewable energy (flow of the river), and instead of setting up a complete closure of the river, it uses the special hydrodynamic characteristics of the floating litter for its separation and collection. With its extendable arms swing out from both sides, the low-cost workboat effectively skims the water for macroplastic particles. On the low flow sections of rivers and on smaller waterways the effects of littering can be managed by other solutions. Among them are the cost-effective river cleanup technologies capable of working **without a permanent staff (see below).**

DESCRIPTION OF HYDR

The implementation of the Hydra Riverine Litter Skimmer Solution, referred to as HYDR, offers several advantages. Firstly, it does not require significant infrastructure modifications, the alteration of coastlines, or the construction of permanent coastal facilities. HYDR operates as a passive waste filtration system, utilising the natural power of the river current to filter and skim litter from the water's surface. Unlike other methods, HYDR does not rely on machinery or built-in drive systems. The fundamental components of HYDR consist of rigid, semi-submerged booms that can be easily interconnected as needed. These modular units form an extended arm, reaching the main flow of the river surface. Research indicates that the majority of floating riverine litter is transported within this main flow, which allows HYDR to effectively address the issue without requiring a complete closure of the riverbed. The guidelines for utilising HYDR depend on whether it is employed in a waterway or a workzone supervised by water engineering experts. Safety measures, such as light and colour signs, must be implemented in both cases. Separate permits are only necessary if the intervention to protect water quality affects a shipping lane. In such instances, in addition to the operator's licence for the specific water area (water authority), licences from the shipping authority must also be obtained. Given that HYDR is deployed periodically, permits need only remain valid for the duration of the waste flow. As for personal safety issues, after completing a brief training session, the staff members are required to adhere to the rules and regulations governing work on water (e.g. obligatory safety equipment). The application of HYDR

[7] https://theoceancleanup.com/rivers/
[8] https://greenfo.hu/hir/ismet-elarasztotta-a-szemet-a-tiszat/
[9] http://www.ovf.hu/hu/korabbi-esemenyek/jon-a-hulladek-a-szamoson
[10] https://petkupa.hu/hu_HU/tobbfrontos-kuzdelem-a-teli-folyami-hulladek-aradattal

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does not require continuous supervision, the collected riverine litter can be handled within a period of 24-48 hours, depending on the level of pollution and the intensity of the plastic flood.

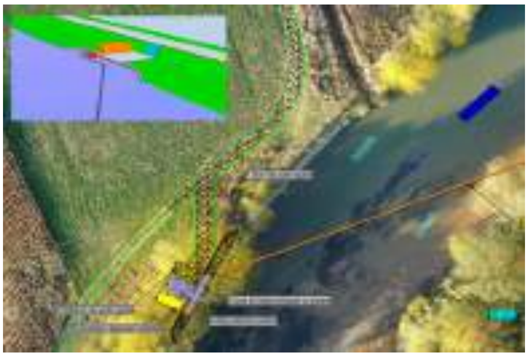
The Plastic Cup Society has been developing solutions to efficiently separate various types of riverine litter at the water level, reducing the need for manual labour. The Hydra riverine litter skimmer is significant for several reasons. It diverts riverine waste instead of blocking it, acting as a primary separator right on the water surface. The collection device harnesses renewable energy from the water flow, making it sustainable and energy efficient. Moreover, HYDR maximises the potential for reuse of the collected riverine waste. Developed by THU, the device will be deployed in water bodies under the jurisdiction of responsible authorities overseeing riverine litter management, such as water authorities and water engineering experts.

The HYDRA riverine litter skimmer (HYDR) is an affordable and low-maintenance device that can be operated with minimal training and expertise, requiring only a small crew. Its modular structure facilitates easy storage, transport, and installation. As part of the project, about 20 HYDR modules will be manufactured and tested in various locations, across different river basins, and under varying flow conditions. Once the project concludes, each pilot area will have the opportunity to acquire 3-5 HYDR modules based on their specific future requirements. In each pilot area, the entity responsible for water management and riverine litter extraction will assume the costs associated with device storage and maintenance. This approach ensures that the operational expenses are borne by the relevant parties in each specific region. By distributing the HYDR modules accordingly, the project aims to maximise their effectiveness and optimise the management of riverine litter in diverse environments. To facilitate replication and adaptation of HYDR, comprehensive technical descriptions and standardised blueprints will be provided for the improved modules. Once the documentation is finalised, all the necessary information to replicate, copy, or adapt HYDR will be made available online, free of charge. This commitment aligns with the core principles of the Plastic Cup initiative, which advocates for open access information as a crucial tool in achieving plastic-free rivers.

DPS-9: Crisuri Water Basin

1. *Short description of DPS emphasizing the part of the pilot that is planned to be replicated (keep in mind that the budget for replication is 100.000 euros).*

   DPS 9 (Crisuri Water Basin Administration), will implement, at the basin scale, 3 **intervention sections** for **waste management** and **cleaning of water courses** by **placing 3 litter traps** in order **to reduce the massive PET pollution** along the cross-border zone on *3 main streams*. One of these interventions may be replicated with the budget of 100.000 euros.



The technical solution is composed of:

- Creation of a **platform** where the floats will be collected.
- Construction of an **access road** to the platform where the floats will be picked up.
- Installation of the **litter trap system** for collecting floaters.

2. *What kind of data you needed to gather before you created, developed and installed your DPS? What kind of hydrological, climatic, environmental, socio-economic data?*

   There was no need to collect concrete data, only several criteria had to be taken into account, such as:
   - **Hydrological** – for the location, the distance from the hydrological measurement stations/places was taken into account in order not to affect the measurements results;
   - **Geomorphologic** – for the most efficient placement of litter-traps, the configuration of the course was also taken into account;
   - **Environmental** – it was considered not to be placed in areas with vegetation in order to have easy access and not to not have a negative effect on the vegetation; and
   - **Socio-economic** – also an important factor was the placement of litter-traps downstream of the localities, to capture as much waste from the population as possible, which could get in the course of the waters.

3. *Describe what goal can be achieved with replication of DPS? What will be the expected outcomes/expected changes and potential benefits of that replication? If possible, please try to list at least one benefit in each of the following categories:*

   ➔ **socio-economic**
   A vision for a better tomorrow through raising awareness of environmental pollution and the effort needed to reduce it; and

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A possible revenue generating source if the collected materials are in high quantity.

- **environmental**
  A cleaner river bed downstream of the emplacement, reducing or even denying the environmental pollution with plastic and other floating materials, which may cause health concerns to human and degradation of fauna and flora;

- **water related**
  Reduced water pollution through plastic bottles (which may contain dangerous substances that upon release can cause unwanted effects) and other floating materials.

4. *What criteria should be analyzed when deciding where to replicate your DPS (part of DPS with value about 100.000 euros)? Please try to list everything what is relevant? For instance, try to list at least one criterion for each of the following categories:*
    - **hydrological criteria** (water quantity, type of river: lowland, mountain river, etc.): Lowland river / main course river / water bays;
    - **climate criteria:** Continental climate;
    - **soil criteria**
    - **geomorphologic criteria:** Cohesive shore / antropic shore;
    - **vegetation criteria:** Vegetation free zone or at least very low density.
    - **water quality:** Floating waste polluted waters.
    - **socio-economic criteria:** Due to the fact that it could be damaged by certain actions of individuals, it is suggested that the location should be surveilled by camera(s) or selected in a safe called area.
    - **tourism:** Wege, Plakate. Not subject of current theme.
    - **recreational:** Not subject of current theme.
    - **wildlife, etc.:** Doesn't influence the well-being of wildlife.

5. *How would you measure previously listed criteria (define what type of attributes: natural, proxy or constructed)? For definition of attributes see description below in italic:*

6. *To your best knowledge, is it easy or complicated to obtain data for previously listed criteria and attributes for other associated regions?*

   - It isn't easy, nor complicated. It needs a little bit of time to gather data, but nothing that cannot be done in a relatively short manner of time.

7. *What are the limitations where your DPS may be replicated? For example, for pilot-constructed wetland replication criteria are settlements with less the 5000 citizens, or locations where an empty lot of size more than 2 ha exists.*

   The limitations are strictly related to the dimensions/specifications of the "litter trap" and its catchment area. The river bed's width should be large enough to ensure that ensemble's emplacement can be done and it's functionality can be fulfilled.

8. *Please suggest specific locations (minimum 5) where your pilot may be replicated (for each location, explain why you think it is suitable to be a replication location in more detail as possible; what are the conditions that make it perfect for your pilot; do you have data for that location and which one (for example climate, natural conditions, socio-economic data, etc.).*

As mentioned above, a few conditions need to be fulfilled so that the implemented measure could be efficient (point 4 of the current questionnaire).

The three locations that make it perfect for our pilot sites are situated in the cross-border region, respectively the lowland of the following main rivers: Barcău river (which has 27 total main tributaries), Crișul Repede river (32 main tributaries) and Crișul Negru river (29 main tributaries). Taking this aspect into consideration, a large amount of floating waste collected from the entire hydrographic basin of the main river, in certain conditions, could be collected in at least one point before crossing the border to the neighbouring state.

We cannot express ourselves, in numbers, related to how much waste was collected in a set amount of time because our three "litter traps" aren't placed at this moment. Either way, once they'll be ready for use, we expect them to function as intended in spring, respectively autumn, or when water level rises due to natural causes and engages different kinds of waste from its major bed.

9. *Now, use objectives/criteria from question 4 to guide the search for locations (associated regions). Focus first on each objective/criterion one at a time and ask yourselves, what are some locations that might measure up well in terms of this objective? Then one considers sets of more than one objective and asks an analogous question. For instance, ask yourself which locations can be good for replications according to water quality criterion? Then, which locations can be good for replications according to hydrological criterion? Etc.*

Going step by step in our guide related to searching of locations in associated regions, we suggest taking, in order, the following criteria:

- The emplacement of a "litter trap" could be considered on a lowland river, respectively on a main course river or a water bay. If a tributary of the main river is considered a main source of waste pollution, it could also be considered as a suitable emplacement area.
- In our situation, the continental climate criteria are present in Eastern Europe, but generally in all of Europe's climates, excepting, probably, the mountain climate.
- For easier assembly and maintenance of the "litter trap", an anthropic shore in a regularized section is best suited. Also, a cohesive shore could be a good option.
- Vegetation is a natural hindrance and, if possible, should not be present in the catchment area.
- A surveilled zone or a safe called area where it will be place is indicated so that human action won't interfere and/or damage parts of the assembly.

10. *For listed locations, try to provide estimation is it possible to obtain data related to previously listed criteria/objectives.*

The authorities of the country where are these locations should have data related to the listed criteria/objective.

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3.3. Summary of questionnaires

Table below displays the list of DALIA Demonstrators Pilots Sites (DPS) replication summary.

DPS	Pilot Site Entity	Problem	Solution	Potential Replication	Type of activity to be Replicated
DPS 1	Széchenyi István University, Győr, Hungary	Heavily modified water bodies (HMWB) due to: - River Regulation, - Floodplain reduction, - Riverbed incision, - Diversion Canal Hydropower Plant	Design, construction and operation of a dynamically controlled water replenishment system on the active and historical floodplains. Involving stakeholders in design and operation decision making processes. Longitudinal and lateral connectivity of river branch systems.	1) designing water body and wildlife habitat rehabilitation 2) stakeholder involvement practices during planning and operation 3) dynamic control of the system 4) design aspects of artificial habitat development and different fish passes	- Revitalisation of ecological systems - Ecosystem monitoring and restoration - Reconnection of floodplains - River connectivity - River rehydration
DPS 2	Catholic University of Eichstätt-Ingolstadt, Germany	Heavily modified water bodies (HMWB) due to: - River Regulation - Floodplain reduction - Riverbed incision - Hydropower Plant (transversal structure) - Lost of longitudinal and lateral connectivity	Floodplain re-connection by technical re-establishment of hydrologic dynamics and restoring of ecological functions: 1) Construction of a eight-kilometre-long bypass stream to restore the longitudinal and lateral connectivity 2) Controlled small floods to mimic natural floodplain dynamics 3) Groundwater lowering to increase groundwater fluctuations	1) Construction of a (controlled) bypass stream 2) Controlled small floods 3) Groundwater lowering 4) Abiotic Monitoring: Hydrology (groundwater level, discharge, soil moisture), Erosion (remote sense data) 5) Biotic Monitoring: Vegetation (macrophytes, riverbank vegetation, forest vegetation), Seeds (neophytes, floodplain vegetation), Amphibians	- Revitalisation of ecological systems - Ecosystem monitoring and restoration - Reconnection of floodplains - River connectivity
DPS 3	T.G. Masaryk Water Resources Institute, Prague, Czech Republic	The area is transitioning into a large, protected floodplain forest, heavily utilizing its water resources for various activities such as industry and conservation. The management involves complex water control systems like weirs and dikes. This forest depends on periodic artificial flooding from a reservoir to maintain its ecosystem. With climate change causing higher evaporation and unchanged precipitation levels, managing water effectively is becoming increasingly challenging in maintaining the area's hydrological balance.	Monitor and Research: Continuously monitor water and weather conditions and conduct research to better understand local impacts of climate change on water resources.	1) Evaporimeter station 2) Reba Tor (Reservoir Balance Calculator)	1) Clarification of evaporation from the water surface by means of a floating evaporimeter 2) The calculation of the reservoir balance which includes not only inflow, minimum residual flow below the reservoir (MRF), and withdrawal but also evaporation from the surface and precipitation onto the surface.
DPS 4	People and Water NGO, Kosice, Slovakia	The Slovak experiment documents the impact of the landscape structure revitalization nature-based measures with retention capacity increase on improving water resources and moderating flash flood risks. To create a network of partners in EU countries who would start the implementation of the methodology of integrated rainwater management in order to connect the needs of water, soil, ecosystem, and climate protection in entire basins. The goal is to include the integrated rainwater management in the plans of integrated management of river basins, so that rainwater, which currently brings risks, becomes a co-creator of increasing economic benefits in the river basin in accordance with the need for permanent regeneration of water resources and soil, strengthening biodiversity and healing the climate.	There are 2 possibilities for replication from the Slovak project. The first option is obtaining water resources by increasing the water-holding capacity of damaged ecosystems in the forest-agricultural landscape through NBS. The second replication, which results from Slovak research, is the development of action plans for basins in which the potential possibility of using rainwater to solve water security for people, food, nature, and the climate is defined.	In the damaged drainage area of 25-50 hectares, implement water retention measures to collect rainwater, which will strengthen percolation into the soil and will supplement the replenishment of soil and groundwater supplies with the subsequent restoration of the depleted groundwater sources of springs. It follows from the preparation Slovakia that it is possible to stop the growth of floods by implementing the entire network of the natural based solutions (NBS), to strengthen the abundance of water resources in the territories, to improve the hydrology of water courses, to improve the fertility of the forestry and agricultural landscape by depositing carbon in ecosystems and soil, to eliminate heat islands over an urbanized landscape, to reduce health risks from overheating the landscape.	Two types of activities according to the interest of the replicators. 1) Processing the potential of obtaining water resources through the NBS, preparation, design, implementation, and monitoring of the impact of the NBS on the hydrology of small watercourses 2) Analyses of the damage to the forest-agricultural and urbanized landscape for the water balance, the proposal of solutions for the restoration of the damaged landscape with the quantification of the benefits, for water resources, soil fertility, forests, the temperature regime of the landscape and carbon sequestration.
DPS 5	University of Novi Sad, Faculty of Agriculture, Serbia	Water quality issues caused by wastewater.	Constructed Wetland System (CWS) for wastewater treatment. They are engineering methods that are designed and built using natural and regular processes that include active ingredients such as vegetation, soils, plant extracts, algae extracts, fungi, and bacteria that are effective in the wetland to assist with wastewater treatment.	1) Designing CWS 2) Part or all of the construction and installation works for CWS, subject to available financing	- Revitalisation of ecological systems - Ecosystem monitoring and restoration

DPS 7	National Institute of Hydrology and Water Management, Romania. Lower Danube University of Galati Romania	Decreasing of suspended sediment transport into the Black Sea and river dredging for navigation purposes are main issues that require better knowledge of suspended sediment load transported by the Danube into the Black Sea, as well as knowledge of sediment quality along the river.	Purchase, installation and use of the continuous monitoring station, containing 5 sensors, to be placed at the mouth of the river, before discharged into the seas/ocean, in order to improve the suspended sediment monitoring. Through the use of historical data and the collection of seasonal and time series data, the resulting database will provide all that is necessary for the development of highly accurate virtual sensors for sediment monitoring. In the same time prediction and forecasting models related to both water quality matrix and sediments, developed on the base of neural network approach can be used for better knowledge of sediment quality.	1) Designing of field campaign to estimate the evolution of suspended sediment budget along the river and the sediment quality 2) Part or all of the construction and installation of the continuous monitoring station 3) Prediction and forecasting models related to both water quality matrix and sediments 4) Guide for deep-learning based framework to develop a more complex monitoring system for physic-chemical parameters	- Sediment management activities – Ecosystem monitoring and restoration
DPS 8	Plastic Cup Society, Hungary	Plastic pollution of rivers: lack of tools and protocols to learn and manage the problem, lack of awareness raising tools and lack of joint responsibility of local people towards the river.	Based on the 10+ years' experience of Plastic Cup, the Riversaver Replication Pack consists of know-how and protocols about organising river monitoring (data management), pollution management (cleanups) and awareness raising. The Riversaver Replication Pack is based on knowledge sharing, involvement and education of local stakeholders and citizen science.	1) Tools (boat, river litter skimmer) and protocols for management of transnational riverine litter (plastic) pollution 2) Tools (River Litter Lab) and protocols for awareness raising (incl. Communication and education) about plastic pollution in rivers 3) Tools (GPS bottle, remote sensing) and protocols for data collection and management (harmonised plastic pollution monitoring in rivers)	- Litter clean up in rivers and connecting ecosystems - Ecosystem monitoring and restoration - Revitalisation of ecological systems
DPS 9	Crisuri Water Basin Administration	Pollution of rivers with PET bottles and other floating materials.	Implementation of intervention sections by placing three litter traps in the cross-border zone of three main streams.	Physical replication: one intervention section. Non-physical replication: A study about some (or all) rivers situated in a given hydrographic basin (or more) to identify problems related to floating waste and such other materials that end up in their respective riverbeds and could possibly transfer to other countries and/or territories, or even in seas and oceans. This study could branch and go in-depth, considering aspects like where/what/why/how and in the end should offer at least two physical or non-physical solutions, a proposed methodology for further implementation (if needed), regarding a way of reducing or even denying floating waste disposal in the studied rivers, considering the legislation of that country.	- Litter clean up in rivers and connecting ecosystems

Suggested regions for replications by all DPS representatives (based on Dalia tool questionnaires):

- Austria: DPS1 (2 locations), DPS2 (4 locations), DPS3 (1 location), DPS5 (1 location)
- Slovenia: DPS1 (2 locations), DPS2 (1 location), DPS4 (1 location), DPS5 (1 location), DPS7 (1 location)
- Croatia: DPS1 (3 locations), DPS3 (1 location), DPS4 (1 location), DPS7 (2 locations)
- Poland: DPS1 (1 location), DPS3 (1 location), DPS4 (1 location)
- Bosnia: DPS3 (1 location), DPS5 (3 locations), DPS7 (1 location), DPS8 (1 location)
- Israel: DPS3 (1 location)
- Ukraine: DPS4 (1 location), DPS7 (1 location), DPS8 (7 location)
- Belgium: DPS4 (1 location)
- Germany: DPS4 (1 location)
- Spain: DPS4 (1 location)
- France: DPS4 (1 location)
- Greece: DPS4 (1 location)

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- Algeria: DPS4 (1 location) – not eligible
- Azerbaijan: DPS4 (1 location) –not eligible
- Italy: DPS4 (1 location)
- Oman: DPS4 (1 location) – not eligible
- Moldova: DPS7 (1 location)

4. ASSESMENT OF ASSOCIATED REGIONS AND THEIR RELEVANCE FOR CONCRETE TRANSFER

4.1. DALIA Tool Fast and Frugal Tree

As we mentioned in Section 1, a Fast and Frugal Tree (FFT) is a simple decision-making model designed to make effective choices quickly and with minimal information. It's part of a broader set of strategies known as heuristics, which are mental shortcuts that help people make decisions more efficiently. These heuristics are particularly useful in environments where time or information is limited, which was the case in the assessment of associated regions and their relevance for concrete transfer.

FFT are characterized by:

- **Simplicity**. They typically have only a few branches, making them easier to use and understand compared to more complex decision-making models. This simplicity is intentional, based on the principle that more information and more complex models do not necessarily lead to better decisions.
- **Speed**. Their straightforward structure allows for rapid decision-making, which is crucial in situations where quick decisions are needed or when the decision-maker has limited time to analyze information.
- **Efficiency**. Despite using less information, fast and frugal trees can be surprisingly accurate and effective. They leverage key pieces of information (cues) that are most predictive of the desired outcome, ignoring less relevant details.
- **Adaptability**. These trees can be tailored to specific decision-making contexts by identifying the most relevant cues for each situation.

The development and use of FFTs challenge the assumption that more information and more complex decision processes always lead to better outcomes. In reality, these trees capitalize on the strengths of human intuition and the ability to identify patterns or cues that are most likely to lead to successful outcomes.

FFTs are applied in various fields, including medicine, finance, and emergency management, where quick and effective decision-making is critical. They demonstrate that a simpler, more intuitive approach can sometimes outperform more complex analytical methods. FFTs are effective because they cut through the noise and focus on the most critical information, making them a powerful tool for decision-making in various fields.

Creating FFT

Creating FFT involves identifying the key factors that influence a decision and structuring them in a simple, hierarchical manner. These trees aim to make effective decisions by using a minimal amount of information, prioritizing speed and simplicity without significantly compromising accuracy. Here's a step-by-step guide to creating one:

Step 1. Define the decision goal

Clearly define the decision you need to make. This goal will guide the development of your tree and help you identify the most relevant information to include.

Step 2. Identify key cues

List the factors (cues) that influence the decision. From this list, select the most critical cues based on their predictive power and relevance to the decision goal. Fast and frugal trees typically use very few cues — often just one to three.

Step 3. Rank the cues

Order the selected cues by their importance and predictive ability. The cue that most directly predicts the outcome or that provides the most significant insight should be placed at the top of the tree.

Step 4. Structure the tree

Build the tree by starting with the most important cue. For each cue, define the decision or action that should be taken if that cue is present (or absent). This typically results in a "yes/no" or binary structure for each cue, guiding the decision-maker through a simple process.

Step 5. Thresholds for decision

For each cue, establish thresholds or criteria that will determine the path taken in the decision tree. These thresholds should be clear and based on objective data when possible.

Step 6. Simplify

Review your tree for any unnecessary complexity and strive to simplify it. The goal is to make the tree as straightforward as possible without losing its effectiveness.

Creating Dalia Tool FFT – general model

Step 1. According to the project proposal the ***Dalia tool*** *will be used for assessment of associated regions and their relevance for concrete transfer.* Also, DALIA tool *will define a methodology for region comparisons* and *select a list of candidate regions for transferring experiences.* We decided to use NUTS 0 (counrty level) for comparisons of regions.

Steps 2 – 3. We identified cues for the Dalia FFT by considering what is written in the DALIA project proposal, the data we received from DPS questionnaires, the data we managed to collect about regions (see Appendix) and based on consultations with the Dalia Project Officer. Because different DPSs proposed different criteria for the assessment of the region, the best way to proceed was to use the minimal number of criteria to avoid any kind of mistake. For the **Dalia FFT – general model** the cues are as follows:

Cue 1: Is this region located in EU member states or in third countries associated with Horizon Europe (Associated countries), other than those that are part of the DALIA project consortium?

Cue 2: Does the region have any local or regional authorities?

Cue 3: Did the region already receive financial support provided under the topic?

Cue 4: Is there any other sub basin in that region that did not receive financial support under the topic?

Cue 5: Does the region have a similar ecosystem to the Danube Basin, or is the region less developed?

Cue 6: Is the region from one of the countries suggested for replication by representatives of DPS?

Cues 1-3 are taken from the Dalia project proposal. **Cue 4** was included after the second project partner online meeting (held on January 30, 2024) and discussions with the Dalia Project Officer.

For **Cue 5**, we used the database of associated regions when answering *'Does the region have a similar ecosystem to the Danube Basin*?' while for the cue *'Is the region less developed?'* we decided that all regions from countries with a nominal GDP per capita lower than $30,000 USD are considered less developed, and regions outside Europe are also considered less developed.

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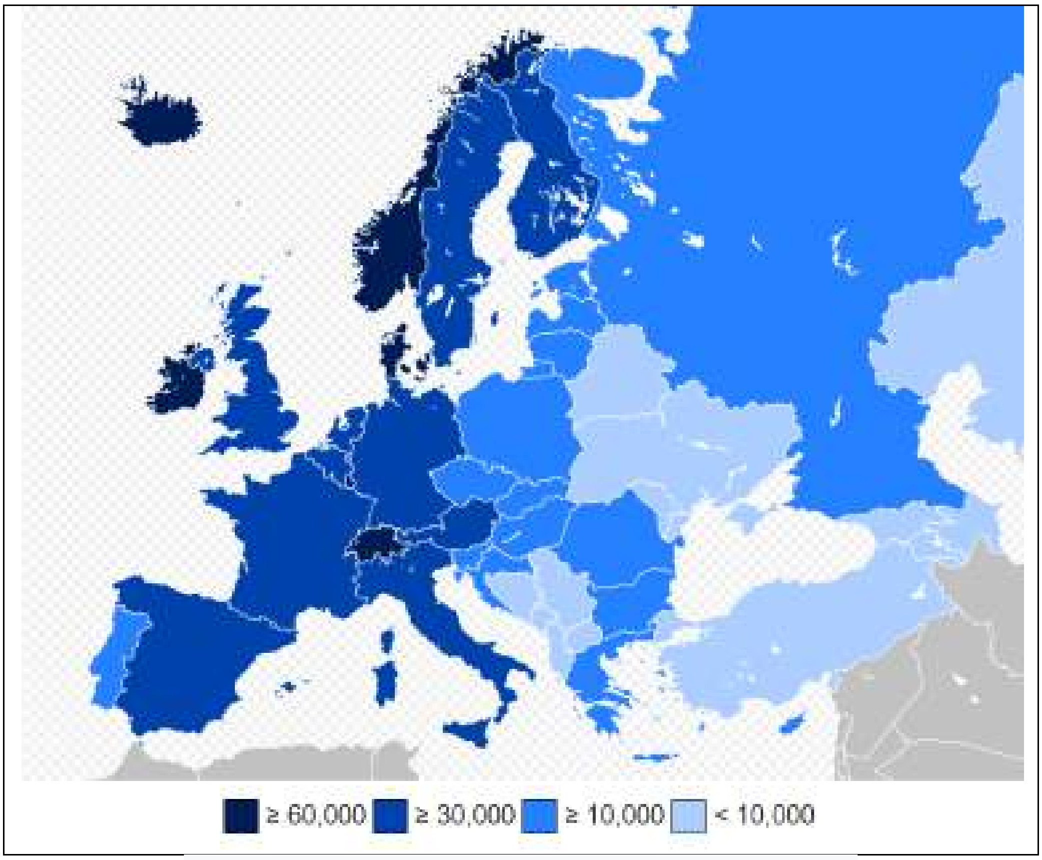


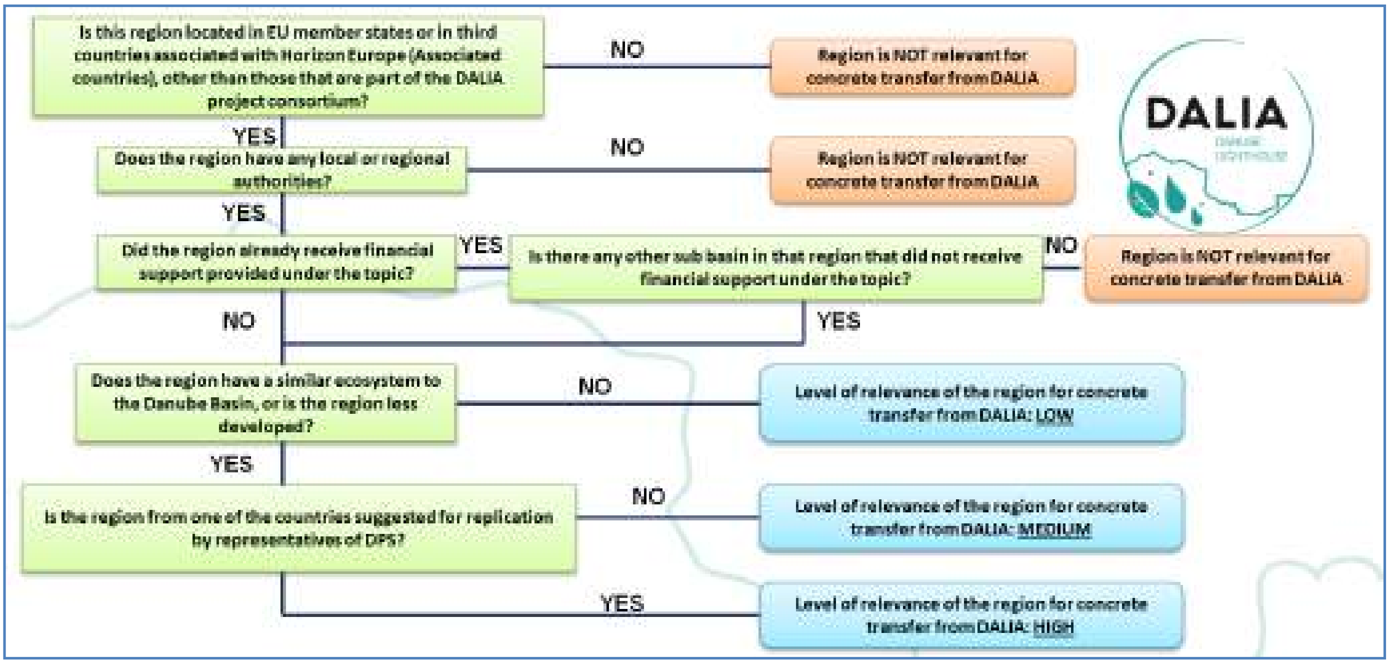
Nominal GDP (in US$) per capita by country (IMF data)

This means that all regions from the following countries are considered less-developed: Croatia, Cyprus, Estonia, Greece, Italy, Latvia, Lithuania, Malta, Poland, Portugal, Slovenia, Albania, Armenia, Bosnia and Herzegovina, Georgia, Israel, Moldova, Montenegro, North Macedonia, Tunisia, Türkiye, and Ukraine.

Finally for **Cue 6**, we used data provided by DPS representatives in the Dalia Tool Questionnaires.

Steps 4 – 6. We avoided unnecessary complexity and simplified DALIA tool FFT. Each cue has binary structure and can be answered with "YES" or "NO", while we have 4 different outputs from Dalia Tool FFT – general model:
Output 1: Region is NOT relevant for concrete transfer from DALIA
Output 2: Level of relevance of the region for concrete transfer from DALIA: LOW
Output 3: Level of relevance of the region for concrete transfer from DALIA: MEDIUM, and
Output 4: Level of relevance of the region for concrete transfer from DALIA: HIGH.

Finally, below is presented the Dalia Tool FFT – general model:



DALIA Tool FFT – general model

Creating Dalia Tool FFT – detailed model

In the **Dalia Tool FFT – detailed model**, the cues are similar, with the only difference being that we analyze all regions to determine which DPS replication is suitable for which regions. Because of this, we have additional cues related to the problems that particular DPS can solve, as well as cues where we have proposed regions by representatives of DPS for transferring these experiences. These data are collected from the Dalia Tool Questionnaires.

In addition, we have 4 different outputs from Dalia Tool FFT – detailed model:

Output 1: Level of relevance of the region for concrete transfer from DPS1: HIGH
Output 2: Level of relevance of the region for concrete transfer from DPS1: MEDIUM
Output 3: Level of relevance of the region for concrete transfer from DPS1: LOW
Output 4: Level of relevance of the region for concrete transfer from DPS2: HIGH
Output 5: Level of relevance of the region for concrete transfer from DPS2: MEDIUM
Output 6: Level of relevance of the region for concrete transfer from DPS2: LOW
Output 7: Level of relevance of the region for concrete transfer from DPS3: HIGH
Output 8: Level of relevance of the region for concrete transfer from DPS3: MEDIUM
Output 9: Level of relevance of the region for concrete transfer from DPS3: LOW
Output 10: Level of relevance of the region for concrete transfer from DPS4: HIGH
Output 11: Level of relevance of the region for concrete transfer from DPS4: MEDIUM
Output 12: Level of relevance of the region for concrete transfer from DPS4: LOW
Output 13: Level of relevance of the region for concrete transfer from DPS5: HIGH
Output 14: Level of relevance of the region for concrete transfer from DPS5: MEDIUM
Output 15: Level of relevance of the region for concrete transfer from DPS5: LOW
Output 16: Level of relevance of the region for concrete transfer from DPS7: HIGH

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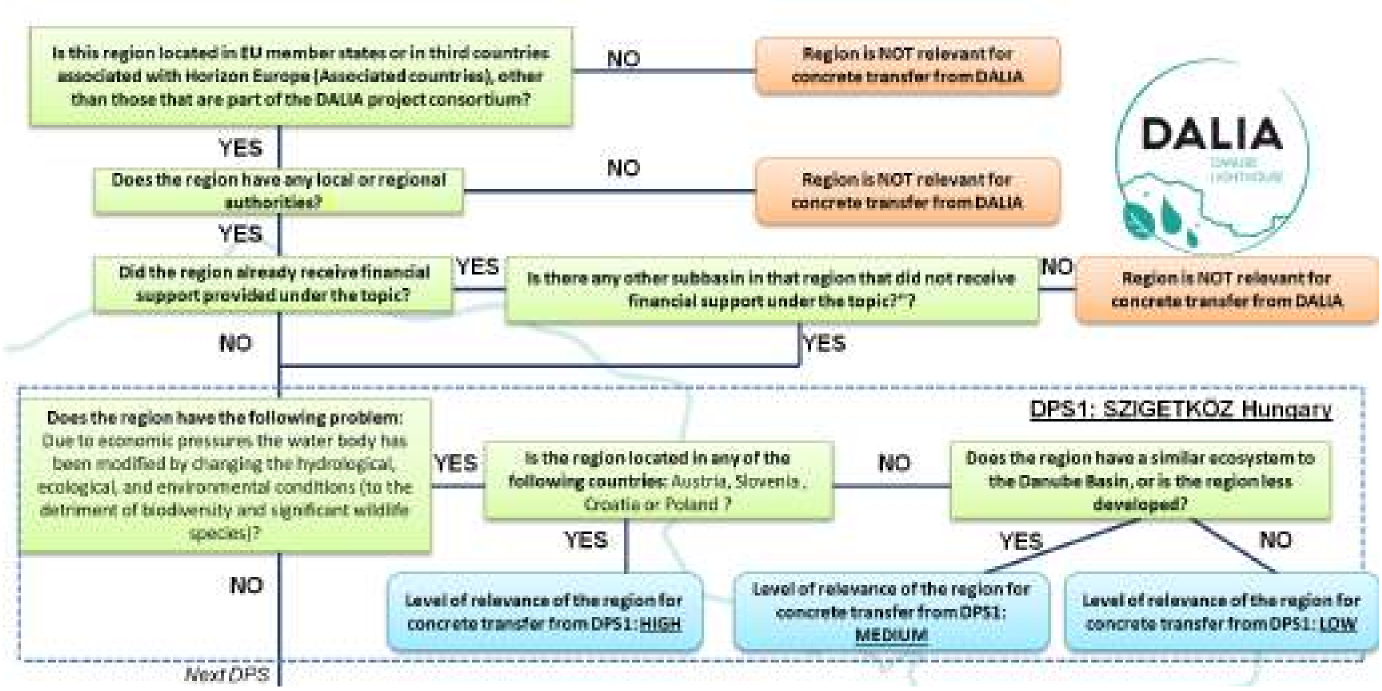
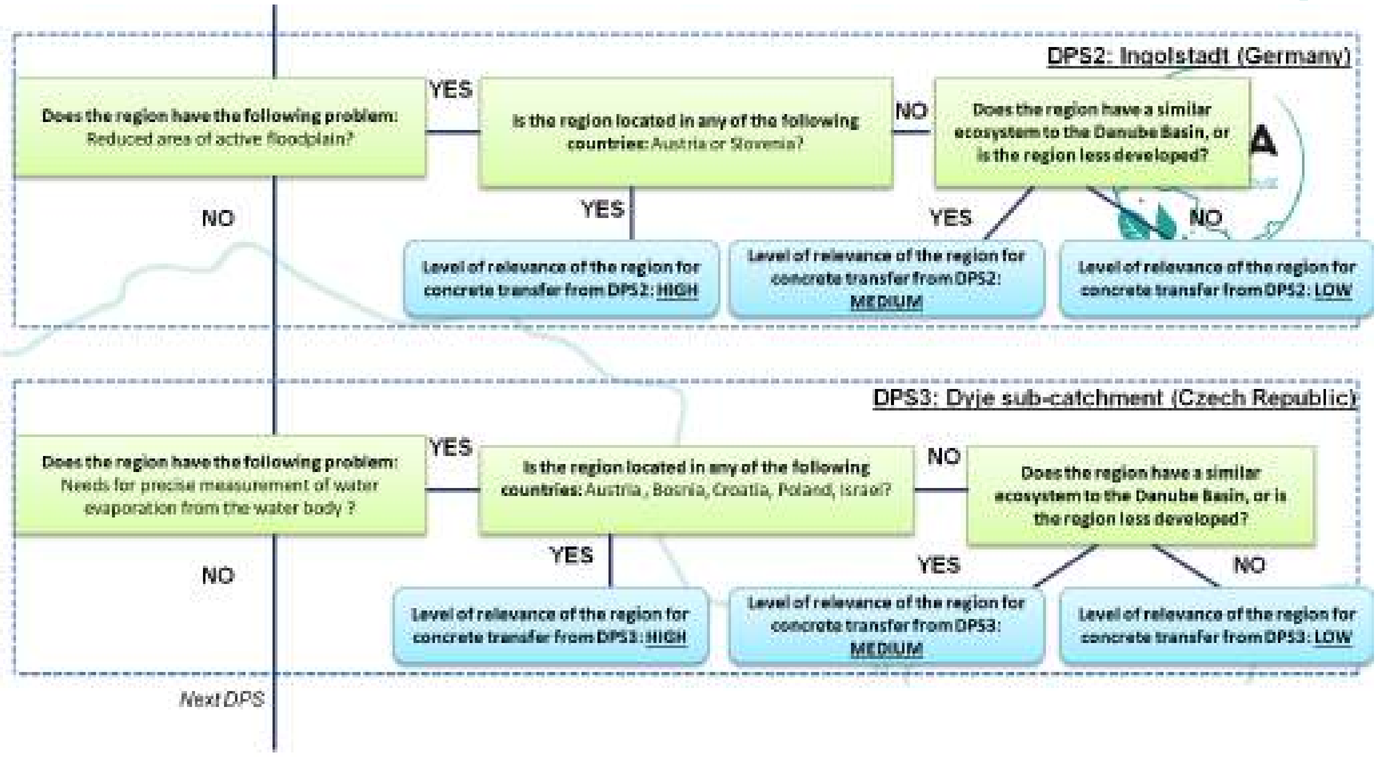
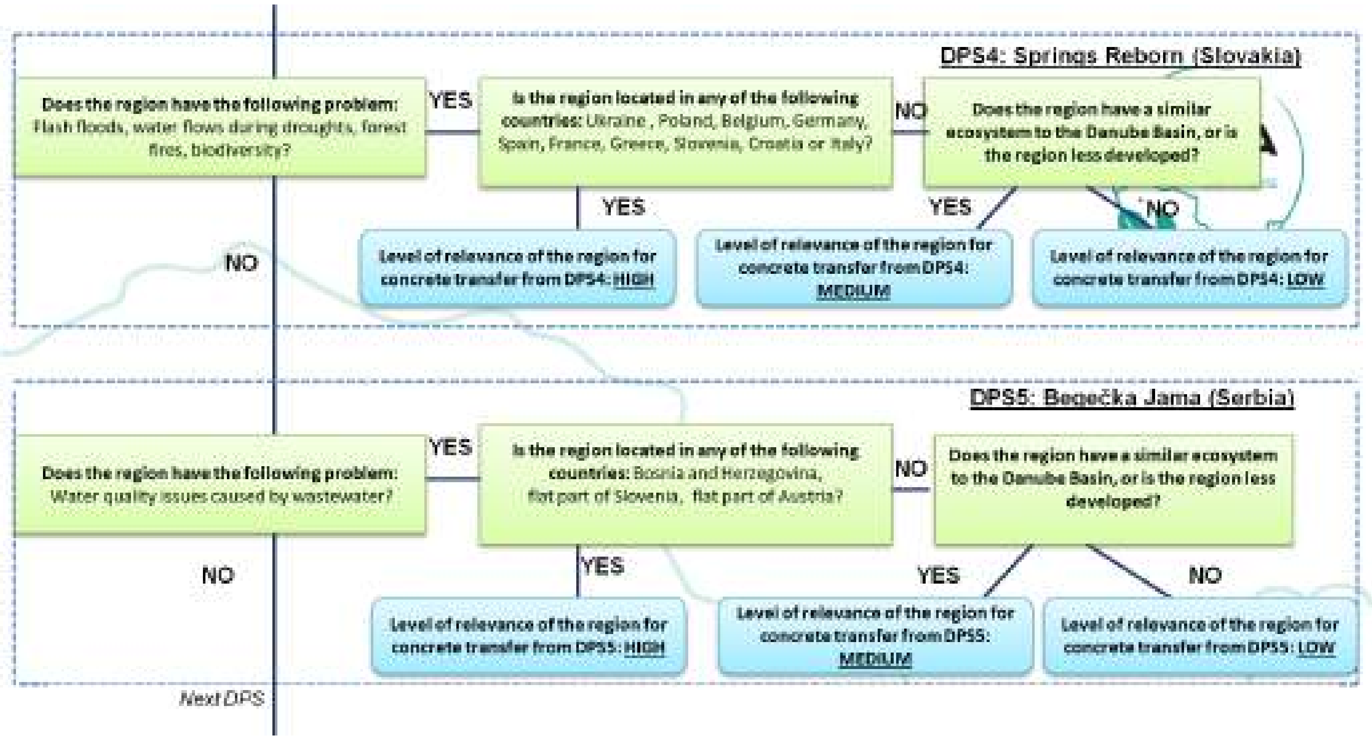
Output 17: Level of relevance of the region for concrete transfer from DPS7: MEDIUM
Output 18: Level of relevance of the region for concrete transfer from DPS7: LOW
Output 19: Level of relevance of the region for concrete transfer from DPS8 and DPS9: HIGH
Output 20: Level of relevance of the region for concrete transfer from DPS8 and DPS9: MEDIUM
Output 21: Level of relevance of the region for concrete transfer from DPS8 and DPS9: LOW
Output 22: Region is NOT relevant for concrete transfer from DALIA

Finally, below is presented Dalia Tool FFT – detailed model:







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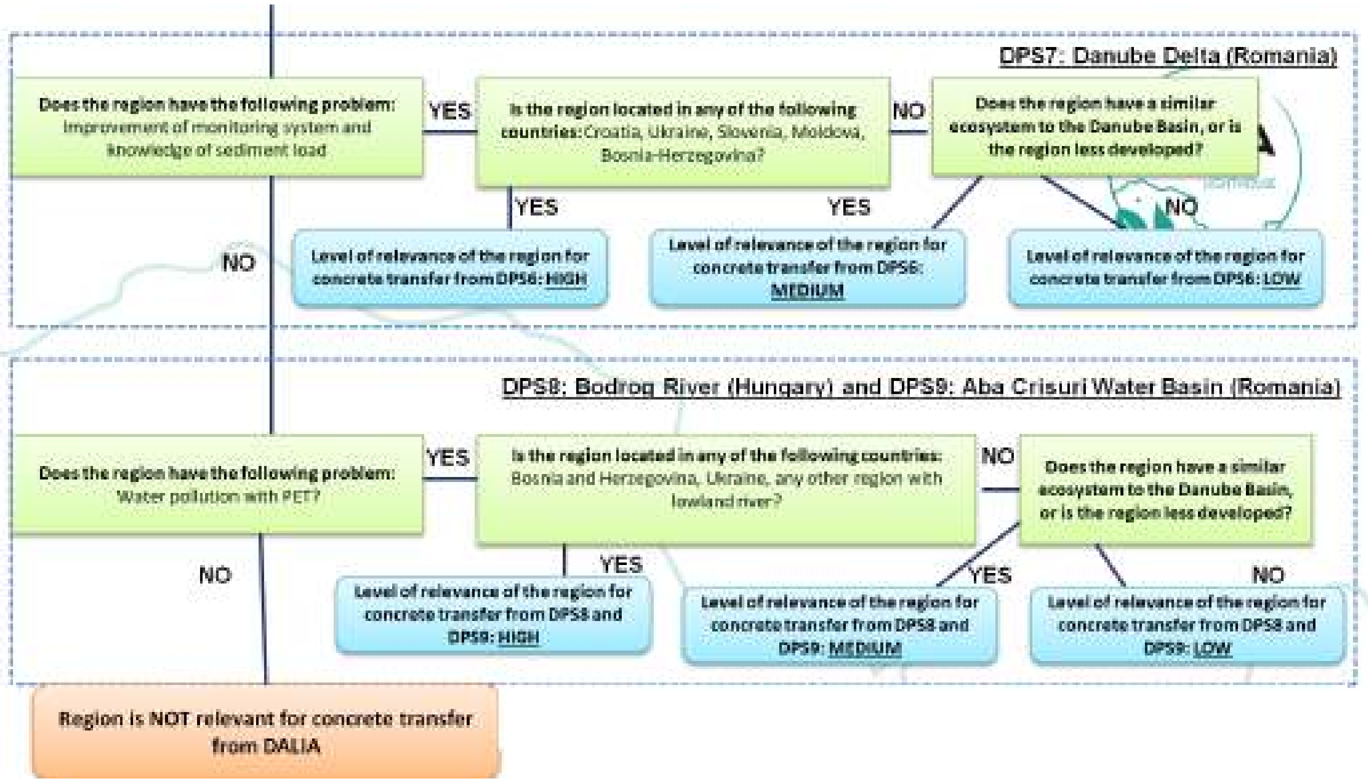

DALIA Tool FFT – detailed model

In the table below are presented results of DALIA tool FFT – general model. From the assessment of associated regions with FFT we can see that totally 13 countries (Austria, Belgium, Bosnia and Herzegovina, Croatia, France, Greece, Israel, Italy, Moldova, Poland, Slovenia, Spain and Ukraine) have high relevance for concrete transfer from DALIA. On the other hand low relevance for concrete transfer from DALIA have following countries: Denmark, Faroe Islands, Finland, Iceland, Luxembourg, Netherlands, Norway, Sweden and United Kingdom.

Assessment of associated regions and their relevance for concrete transfer with DALIA Tool FFT – general model

	Level of relevance of the region for concrete transfer from different DPSs:
Albania	M (medium)
Armenia	M (medium)
Austria	H (high)
Belgium	H (high)
Bosnia	H (high)
Bulgaria	NR (not relevant)
Croatia	H (high)
Cyprus	M (medium)
Czechia	NR (not relevant)
Denmark	L (low)
Estonia	M (medium)
Faroe Islands	L (low)
Finland	L (low)
France	H (high)
Germany	NR (not relevant)
Georgia	M (medium)
Greece	H (high)
Iceland	L (low)
Ireland	NR (not relevant)
Israel	H (high)
Italy	H (high)
Hungary	NR (not relevant)
Latvia	M (medium)
Lithuania	M (medium)
Luxembourg	L (low)
Malta	M (medium)
Moldova	H (high)
Montenegro	M (medium)
Netherlands	L (low)
North Maced.	M (medium)
Norway	L (low)
Poland	H (high)
Portugal	M (medium)
Romania	NR (not relevant)
Serbia	NR (not relevant)
Slovenia	H (high)
Slovakia	NR (not relevant)
Spain	H (high)
Sweden	L (low)
Switzerland	NR (not relevant)
Tunisia	M (medium)
Türkiye	M (medium)
Ukraine	H (high)
United Kingdom	L (low)

In the figure below, the results of the DALIA tool FFT – general model are presented graphically.

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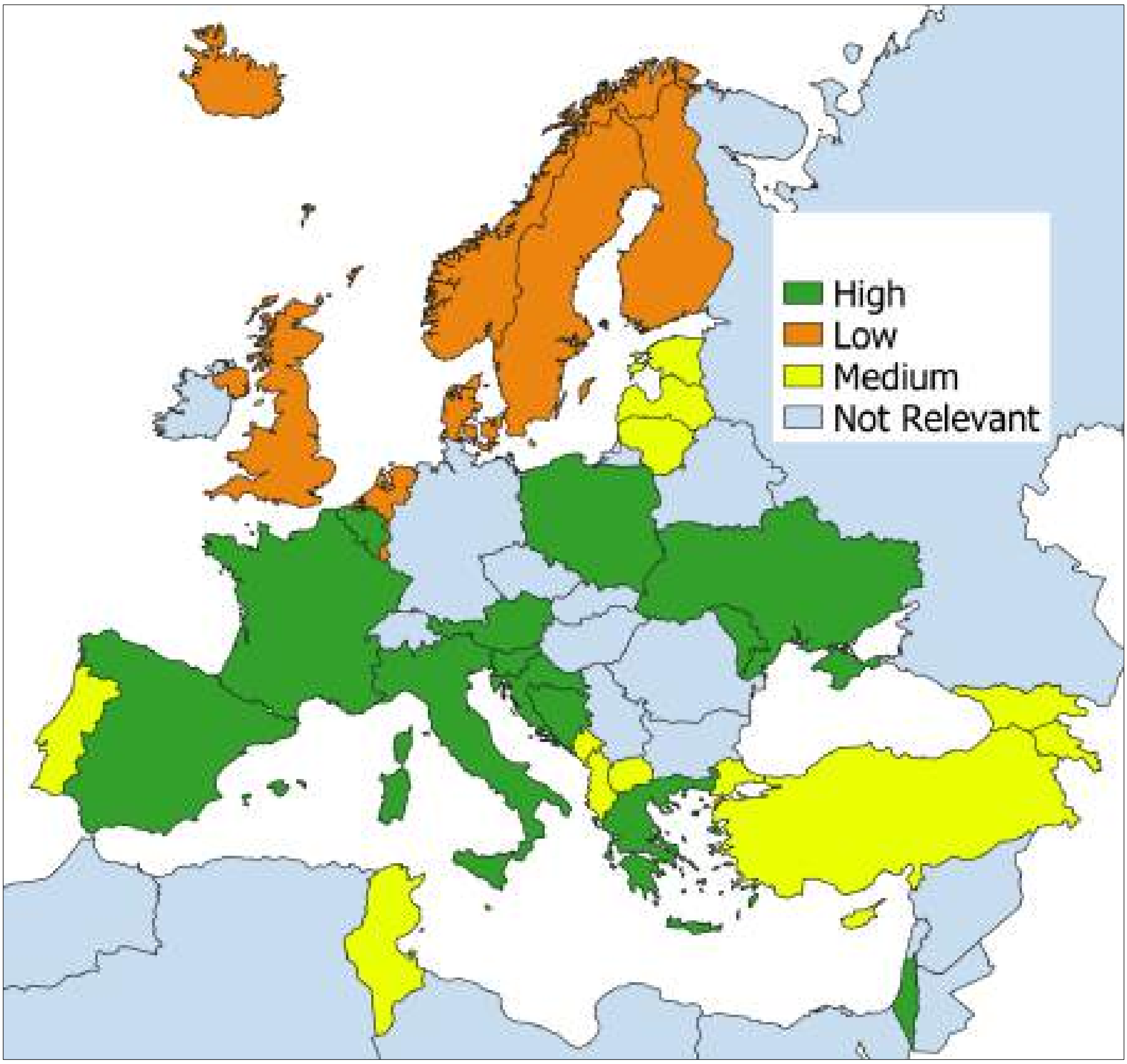

Map representing the assessment of associated regions and their relevance for concrete transfer using the DALIA Tool FFT – general model

In the table below the results of DALIA tool FFT – detailed model are presented.

Assessment of associated regions and their relevance for concrete transfer with DALIA Tool FFT – detailed model

	Level of relevance of the region for concrete transfer from different DPSs: H (high); M (medium); L (low); NR (not relevant)								
	DPS1	DPS2	DPS3	DPS4	DPS5	DPS6	DPS7	DPS8	DPS9
Albania	M	M	M	M	M	NR	M	M	M
Armenia	M	M	M	M	M	NR	M	M	M
Austria	H	H	H	L	H	NR	L	L	L
Belgium	L	L	L	H	L	NR	L	L	L
Bosnia	M	M	H	M	H	NR	H	H	H
Bulgaria	NR	NR	NR	NR	NR	NR	NR	NR	NR
Croatia	H	M	H	H	M	NR	H	M	M
Cyprus	M	M	M	M	M	NR	M	M	M
Czechia	NR	NR	NR	NR	NR	NR	NR	NR	NR
Denmark	L	L	L	L	L	NR	L	L	L

Estonia	M	M	M	M	M	NR	M	M	M
Faroe Islands	L	L	L	L	L	NR	L	L	L
Finland	L	L	L	L	L	NR	L	L	L
France	L	L	L	H	L	NR	L	L	L
Germany	NR	NR	NR	NR	NR	NR	NR	NR	NR
Georgia	M	M	M	M	M	NR	M	M	M
Greece	M	M	M	H	M	NR	M	M	M
Iceland	L	L	L	L	L	NR	L	L	L
Ireland	NR	NR	NR	NR	NR	NR	NR	NR	NR
Israel	M	M	H	M	M	NR	M	M	M
Italy	M	M	M	H	M	NR	M	M	M
Hungary	NR	NR	NR	NR	NR	NR	NR	NR	NR
Latvia	M	M	M	M	M	NR	M	M	M
Lithuania	M	M	M	M	M	NR	M	M	M
Luxembourg	L	L	L	L	L	NR	L	L	L
Malta	M	M	M	M	M	NR	M	M	M
Moldova	M	M	M	M	M	NR	H	M	M
Montenegro	M	M	M	M	M	NR	M	M	M
Netherlands	L	L	L	L	L	NR	L	L	L
North Maced.	M	M	M	M	M	NR	M	M	M
Norway	L	L	L	L	L	NR	L	L	L
Poland	H	M	H	H	M	NR	M	M	M
Portugal	M	M	M	M	M	NR	M	M	M
Romania	NR	NR	NR	NR	NR	NR	NR	NR	NR
Serbia	NR	NR	NR	NR	NR	NR	NR	NR	NR
Slovenia	H	H	M	H	H	NR	H	M	M
Slovakia	NR	NR	NR	NR	NR	NR	NR	NR	NR
Spain	L	L	L	H	L	NR	L	L	L
Sweden	L	L	L	L	L	NR	L	L	L
Switzerland	NR	NR	NR	NR	NR	NR	NR	NR	NR
Tunisia	M	M	M	M	M	NR	M	M	M
Türkiye	M	M	M	M	M	NR	M	M	M
Ukraine	M	M	M	H	M	NR	H	H	H
United Kingdom	L	L	L	L	L	NR	L	L	L

In the figure below, the results of the DALIA tool FFT – detailed model are presented graphically.

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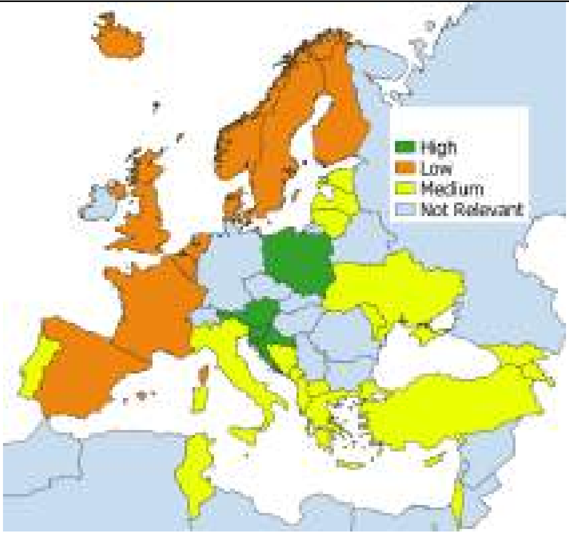
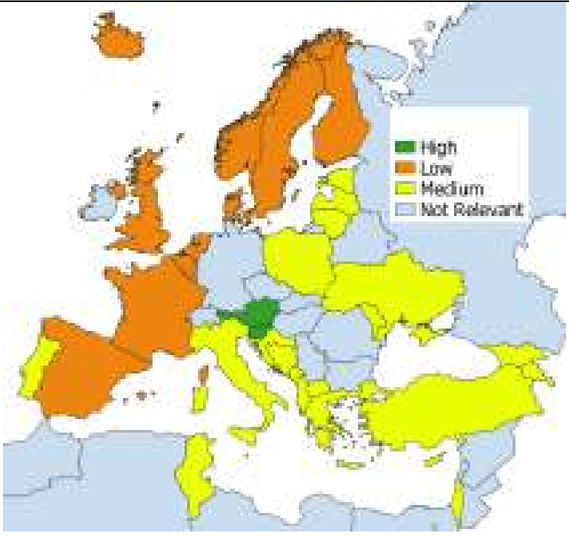


DPS1



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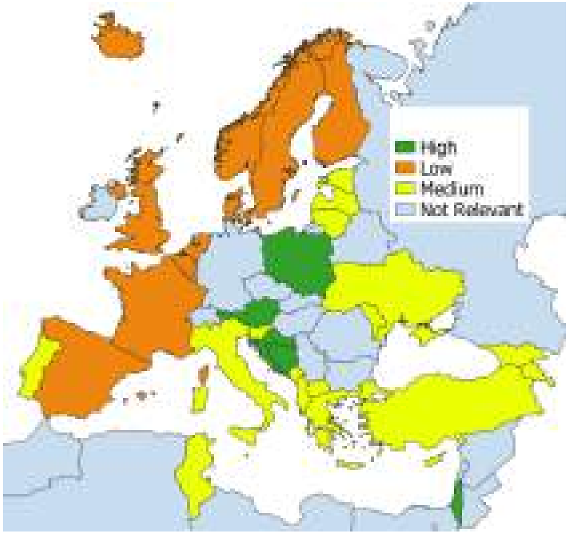

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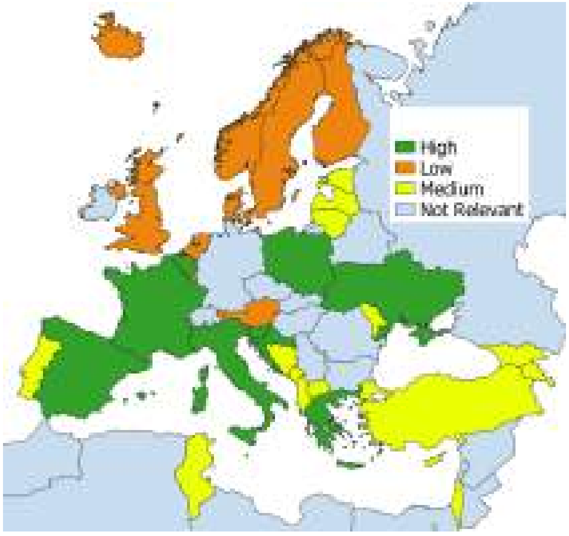

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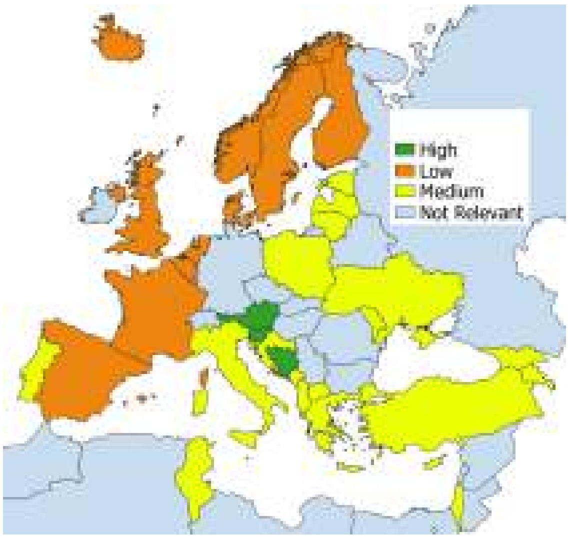

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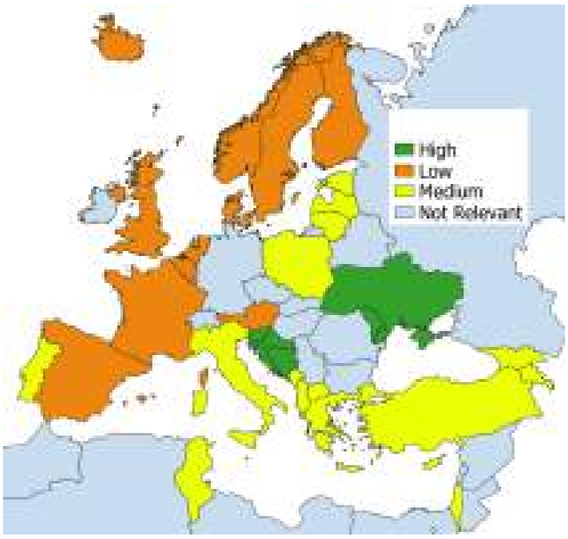
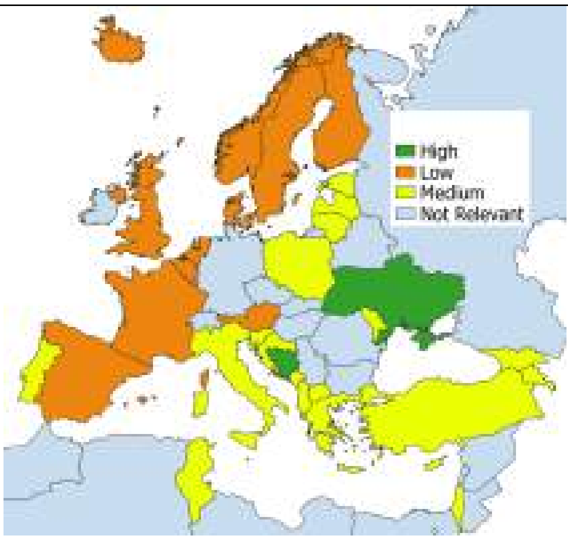
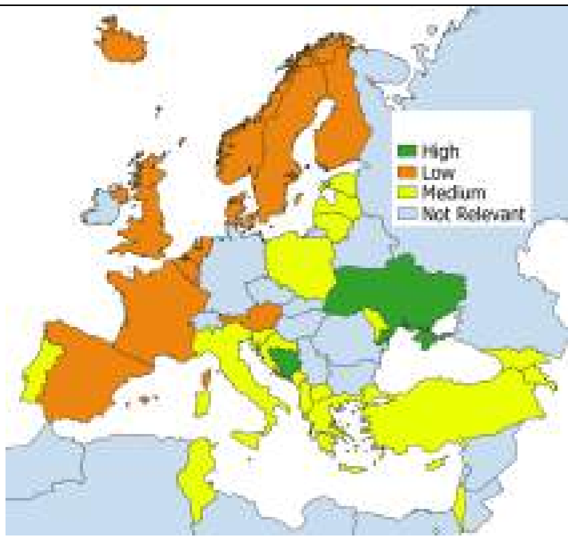


DPS7



DPS8



DPS9

Map representing the assessment of associated regions and their relevance for concrete transfer using the DALIA Tool FFT – detailed model

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4.2. Combining Borda count and Approval voting with results obtained with DALIA tool FFT in order to obtain rankings of associated regions

However, in order to obtain more detailed information regarding the assessment and relevance of associated regions for concrete transfer from DALIA, we combined Social Choice Theory Systems with the results from the DALIA tool FFT detailed model in the following way:

- First, we used the Borda count. Countries with high relevance for concrete transfer from DALIA received 3 points, countries with medium relevance received 2 points, countries with low relevance received 1 point, and countries that are not relevant received 0 points.
- Second, we used Approval Voting. Countries with high relevance for concrete transfer from DALIA received 1 point (approved by DPS), while all other countries received 0 points (not approved).

If we look at the results of combining the Borda count and the DALIA Tool FFT – detailed model for the assessment of associated regions and their relevance for concrete transfer, we can see that the countries with the highest points, and thus most relevant for concrete transfer, are as follows: Bosnia and Herzegovina (21 points), Slovenia (21 points), Croatia (20 points), Ukraine (20 points), Poland (19 points), Greece (17 points), Israel (17 points), Italy (17 points), and Moldova (17 points). For more details and the assessment of other countries, please see the table below.

Combining Borda count and results of DALIA Tool FFT – detailed model for assessment of associated regions and their relevance for concrete transfer

	Level of relevance of the region for concrete transfer from different DPSs: H = 3 points; M=2 points; L=1 points; NR=points									Sum
	DPS1	DPS2	DPS3	DPS4	DPS5	DPS6	DPS7	DPS8	DPS9	
Albania	2	2	2	2	2	0	2	2	2	**16**
Armenia	2	2	2	2	2	0	2	2	2	**16**
Austria	3	3	3	1	3	0	1	1	1	**16**
Belgium	1	1	1	3	1	0	1	1	1	**10**
Bosnia	2	2	3	2	3	0	3	3	3	**21**
Bulgaria	0	0	0	0	0	0	0	0	0	**0**
Croatia	3	2	3	3	2	0	3	2	2	**20**
Cyprus	2	2	2	2	2	0	2	2	2	**16**
Czechia	0	0	0	0	0	0	0	0	0	**0**
Denmark	1	1	1	1	1	0	1	1	1	**8**
Estonia	2	2	2	2	2	0	2	2	2	**16**
Faroe Isl.	1	1	1	1	1	0	1	1	1	**8**
Finland	1	1	1	1	1	0	1	1	1	**8**
France	1	1	1	3	1	0	1	1	1	**10**
Germany	0	0	0	0	0	0	0	0	0	**0**
Georgia	2	2	2	2	2	0	2	2	2	**16**
Greece	2	2	2	3	2	0	2	2	2	**17**
Iceland	1	1	1	1	1	0	1	1	1	**8**
Ireland	0	0	0	0	0	0	0	0	0	**0**
Israel	2	2	3	2	2	0	2	2	2	**17**
Ita1y	2	2	2	3	2	0	2	2	2	**17**
Hungary	0	0	0	0	0	0	0	0	0	**0**
Latvia	2	2	2	2	2	0	2	2	2	**16**
Lithuania	2	2	2	2	2	0	2	2	2	**16**
Luxembourg	1	1	1	1	1	0	1	1	1	**8**
Malta	2	2	2	2	2	0	2	2	2	**16**
Moldova	2	2	2	2	2	0	3	2	2	**17**
Montenegro	2	2	2	2	2	0	2	2	2	**16**
Netherlands	1	1	1	1	1	0	1	1	1	**8**
N. Maced.	2	2	2	2	2	0	2	2	2	**16**
Norway	1	1	1	1	1	0	1	1	1	**8**
Poland	3	2	3	3	2	0	2	2	2	**19**
Portugal	2	2	2	2	2	0	2	2	2	**16**
Romania	0	0	0	0	0	0	0	0	0	**0**
Serbia	0	0	0	0	0	0	0	0	0	**0**
S1ovenia	3	3	2	3	3	0	3	2	2	**21**
Slovakia	0	0	0	0	0	0	0	0	0	**0**
Spain	1	1	1	3	1	0	1	1	1	**10**
Sweden	1	1	1	1	1	0	1	1	1	**8**
Switzerland	0	0	0	0	0	0	0	0	0	**0**
Tunisia	2	2	2	2	2	0	2	2	2	**16**
Türkiye	2	2	2	2	2	0	2	2	2	**16**
Ukraine	2	2	2	3	2	0	3	3	3	**20**
Un. Kingdom	1	1	1	1	1	0	1	1	1	**8**

In the figure below, the assessment of associated regions and their relevance for concrete transfer using the Borda count and the results of the DALIA Tool FFT – detailed model are presented graphically.

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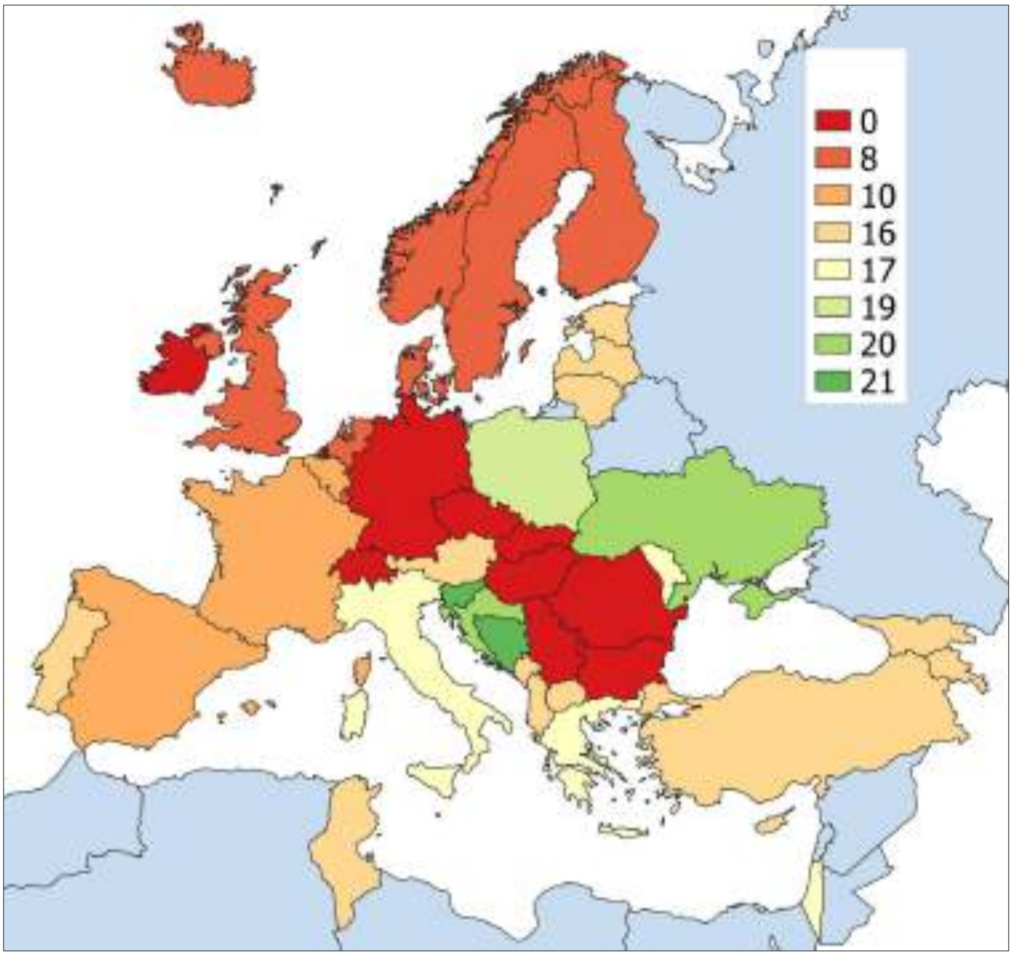

Map representing the assessment of associated regions and their relevance for concrete transfer using the Borda count and results of DALIA Tool FFT – detailed model

If we look at the results of combining the Approval Voting and the DALIA Tool FFT – detailed model for the assessment of associated regions and their relevance for concrete transfer, we can see that the countries with the highest points, and thus most relevant for concrete transfer, are as follows: Bosnia and Herzegovina (5 points), Slovenia (5 points), Croatia (4 points), Ukraine (4 points), Austria (4 points), and Poland (3 points). The obtained results are very logical because the top five countries (Bosnia and Herzegovina, Slovenia, Croatia, Ukraine and Austria) are all more or less from the Danube basin. For more details and the assessment of other countries, please see the table below.

Combining Approval voting and results of DALIA Tool FFT – detailed model for assessment of associated regions and their relevance for concrete transfer

	Level of relevance of the region for concrete transfer from different DPSs: H = 1 point (approved); M =0; L=0; NR =0									Sum
	DPS1	DPS2	DPS3	DPS4	DPS5	DPS6	DPS7	DPS8	DPS9	
Albania	0	0	0	0	0	0	0	0	0	**0**
Armenia	0	0	0	0	0	0	0	0	0	**0**
Austria	1	1	1	0	1	0	0	0	0	**4**
Belgium	0	0	0	1	0	0	0	0	0	**1**
Bosnia	0	0	1	0	1	0	1	1	1	**5**
Bulgaria	0	0	0	0	0	0	0	0	0	**0**
Croatia	1	0	1	1	0	0	1	0	0	**4**
Cyprus	0	0	0	0	0	0	0	0	0	**0**
Czechia	0	0	0	0	0	0	0	0	0	**0**
Denmark	0	0	0	0	0	0	0	0	0	**0**
Estonia	0	0	0	0	0	0	0	0	0	**0**

Faroe Isl.	0	0	0	0	0	0	0	0	0	**0**
Finland	0	0	0	0	0	0	0	0	0	**0**
France	0	0	0	1	0	0	0	0	0	**1**
Germany	0	0	0	0	0	0	0	0	0	**0**
Georgia	0	0	0	0	0	0	0	0	0	**0**
Greece	0	0	0	1	0	0	0	0	0	**1**
Iceland	0	0	0	0	0	0	0	0	0	**0**
Ireland	0	0	0	0	0	0	0	0	0	**0**
Israel	0	0	1	0	0	0	0	0	0	**1**
Italy	0	0	0	1	0	0	0	0	0	**1**
Hungary	0	0	0	0	0	0	0	0	0	**0**
Latvia	0	0	0	0	0	0	0	0	0	**0**
Lithuania	0	0	0	0	0	0	0	0	0	**0**
Luxembourg	0	0	0	0	0	0	0	0	0	**0**
Malta	0	0	0	0	0	0	0	0	0	**0**
Moldova	0	0	0	0	0	0	1	0	0	**1**
Montenegro	0	0	0	0	0	0	0	0	0	**0**
Netherlands	0	0	0	0	0	0	0	0	0	**0**
N. Maced.	0	0	0	0	0	0	0	0	0	**0**
Norway	0	0	0	0	0	0	0	0	0	**0**
Poland	1	0	1	1	0	0	0	0	0	**3**
Portugal	0	0	0	0	0	0	0	0	0	**0**
Romania	0	0	0	0	0	0	0	0	0	**0**
Serbia	0	0	0	0	0	0	0	0	0	**0**
Slovenia	1	1	0	1	1	0	1	0	0	**5**
Slovakia	0	0	0	0	0	0	0	0	0	**0**
Spain	0	0	0	1	0	0	0	0	0	**1**
Sweden	0	0	0	0	0	0	0	0	0	**0**
Switzerland	0	0	0	0	0	0	0	0	0	**0**
Tunisia	0	0	0	0	0	0	0	0	0	**0**
Türkiye	0	0	0	0	0	0	0	0	0	**0**
Ukraine	0	0	0	1	0	0	1	1	1	**4**
Un. Kingdom	0	0	0	0	0	0	0	0	0	**0**

In the figure below, the assessment of associated regions and their relevance for concrete transfer using the Approval voting and the results of the DALIA Tool FFT – detailed model are presented graphically.

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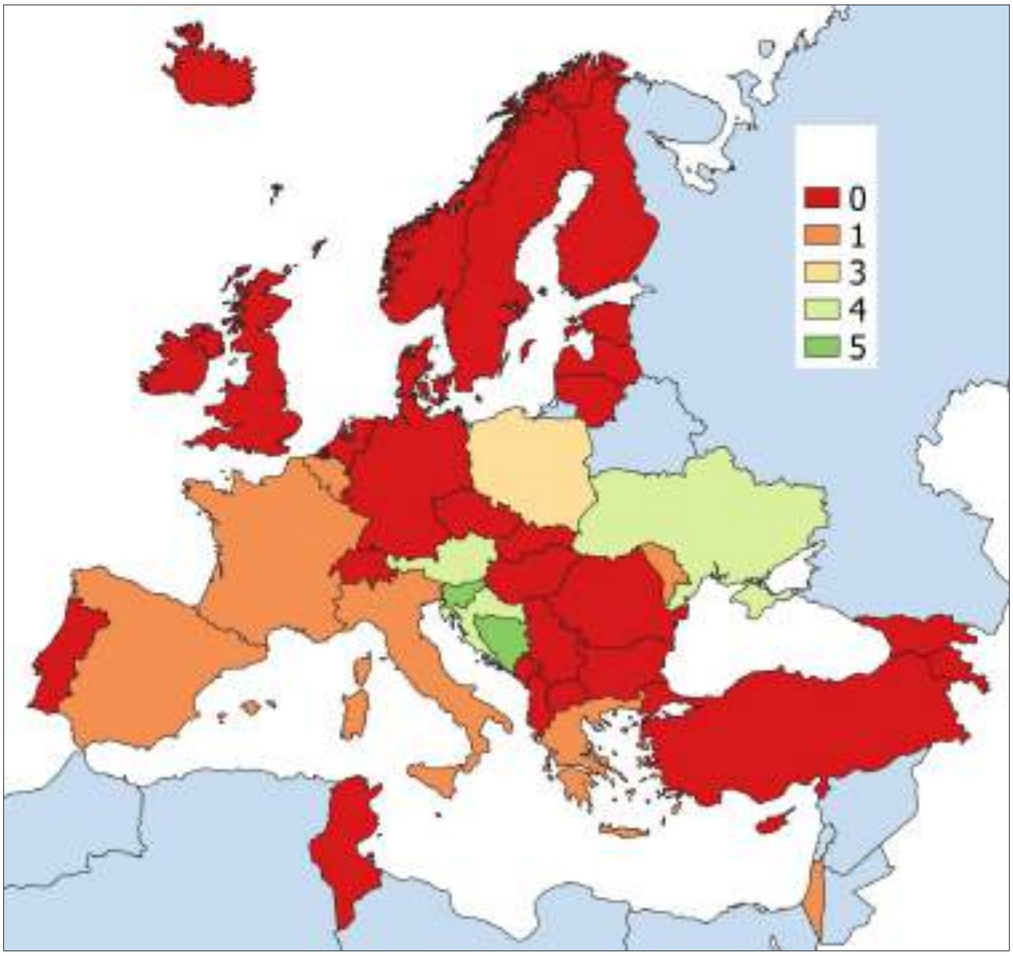

Map representing the assessment of associated regions and their relevance for concrete transfer using the Approval voting and results of DALIA Tool FFT – detailed model

ANNEX NO 1. DATABASE OF ASSOCIATED REGIONS

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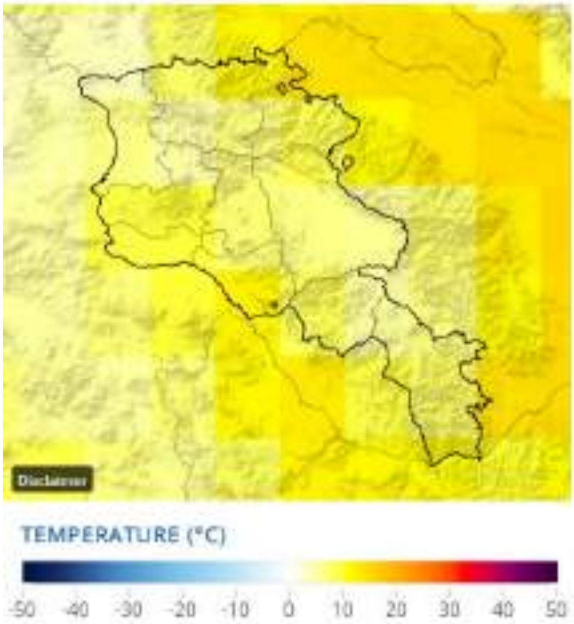
Armenia

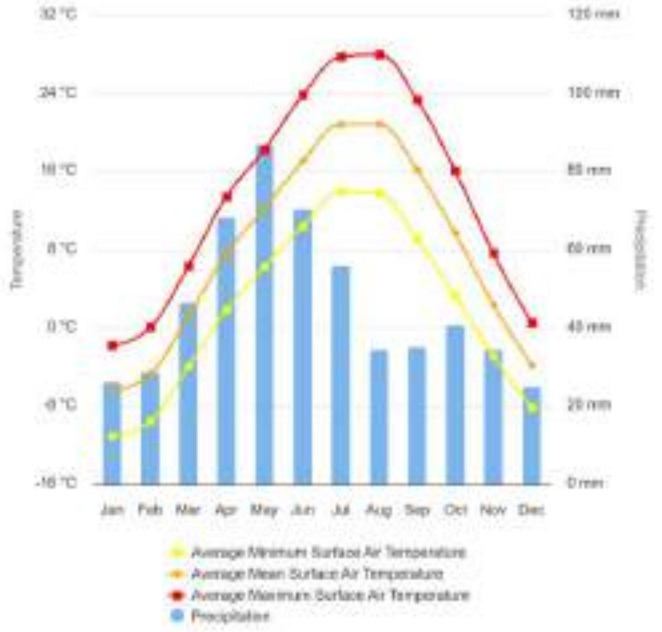
Armenia is a land-locked country within the Caucasus region between Europe and Asia. The majority of the country is at high altitude (greater than 1,000 m.a.s.l.), including Lake Sevan, a freshwater lake, with a surface area of 1,279 km^2 and the Sevan River Basin with a surface area of 4,721 km^2, spans approximately one sixth of the nation's total land area. As of 2019, Armenia's population was estimated at 2.95 million people (2020) and its GDP at $13.6 billion. Around one third of the nation's population lives in its capital city, Yerevan. Over the past decade, Armenia has transitioned from an industry-dominated to a service-dominated economy. As of 2016, the service sector constituted 48.8% of the labor force. Agriculture remains a major employer with a labor market share of 35.3% and there remains a relatively high rate of unemployment (18%) as well as net out-migration (Climate Knowledge Portal World Bank, n.d.).

Map of Armenia (World Atlas, n.d.)

Climate

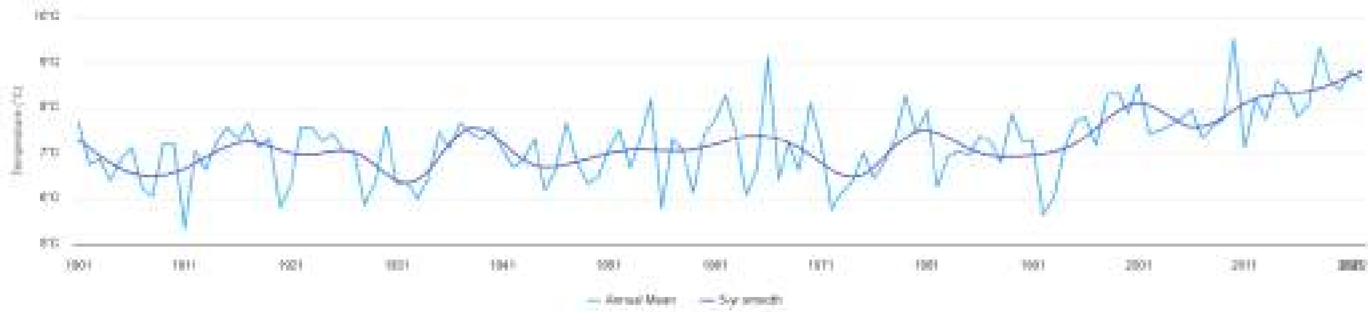
Armenia's climate can be described as highland continental, with large variation between summer highs (June to August) and winter lows (December to February). The country also experiences large climatic contrasts because of its intricate terrain, and the climates range from arid to sub-tropical and to cold, high mountains. Summer highs in Armenia's capital Yerevan average around 30ºC–33ºC while the average in winter is 1ºC–3ºC. The more mountainous regions experience lower average temperatures and prolonged periods of snow cover. The average annual precipitation is low at 526 mm. Precipitation intensity is greater in Armenia's high-altitude regions with May and June the wettest months. For Armenia, altitude is the strongest controlling factor determining the spatial distribution of temperatures and precipitation. Sub-zero average temperatures are common in Armenia's mountain ranges while its highest average temperatures are experienced in the relatively low-lying western plains. Similarly, Armenia's highest peaks may receive up to 1,000 mm of annual precipitation while precipitation can be as low as 200 mm in the western plains (Climate Knowledge Portal World Bank, n.d.).





Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Armenia. (Climate Knowledge Portal World Bank, n.d.)

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2020; Armenia. (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature of Armenia for 1901-2022. (Climate Knowledge Portal World Bank, n.d.)

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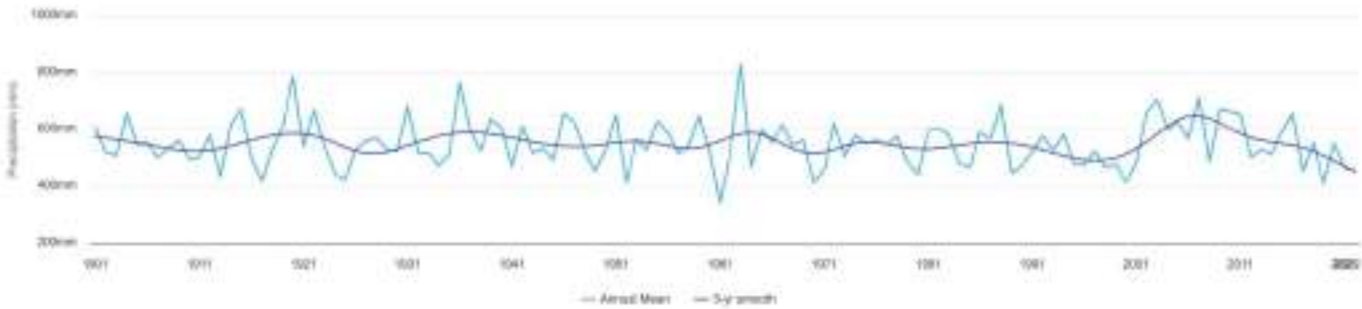
Observed Climatology of Percipitation 1991-2020; Armenia. (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Percipitation of Armenia for 1901-2022. (Climate Knowledge Portal World Bank, n.d.)

Hydrology

The rivers in Armenia are tributaries of the main rivers of the southern Caucasus, namely the Araks and the Kura. About 76% of the total territory is part of the Araks basin and 24% of the Kura basin. Total outflow is equal to the total internal renewable water resources (10^9 m^3/year). The outflow to Georgia through the Debet river is estimated at about 0.89 km^3/year and the outflow to Azerbaijan through the Agstay river at about 0.35 km^3/year; both these rivers are located in the Kura basin. The total outflow to Azerbaijan through the Araks and its tributaries (Arpa, Vorotan, Vokhchi) is estimated at about 5.62 km^3/year. The Araks river forms the border between Turkey and Armenia and further downstream, between the Islamic Republic of Iran and Armenia, it flows into Azerbaijan, joining the Kura river about 150 km before its mouth at the Caspian Sea. The border flow of the Akhuryan (with Turkey) is estimated at 1.03 km^3/year and the Araks at 0.79 km^3/year. Half of the border flow is accounted for in Armenia's water balance, bringing the total actual renewable water resources to 7.769 km^3/year. The 14 sub-basins of the two main river basins (Kura and Araks) have been grouped into five basin management areas: Akhuryan, Northern, Sevan-Hrazdan, Ararat and Southern. About 9,500 rivers and streams with a total length of 23,000 km flow in Armenia. Out of that number, 379 rivers are around 10-100 km long and seven, namely the Akhuryan, Debet, Vorotan, Hrazdan, Aghstev, Arpa and Metsamor-Kasakh, are longer than 100 km. Armenian rivers are typically of a mountainous nature, with sharp seasonal variations, spring freshets and low water flow in summer. Armenia has more than 100 small lakes, some of which regularly dry out in the dry season. (Water Action Hub, n.d.)

Water quantity

According to World Bank. (2021) uncertainty remains around the precise trajectory of future change in the availability of water resources in Armenia and river flows are expected to reduce dramatically. While vulnerability for basin and watersheds vary, under a 'worst-case scenario', average decrease in river flow is estimated at 39% by the end of the century (Ministry of Environment, 2020). These changes would have a significant impact on the levels of Armenia's lakes and reservoirs, with implication for society potentially coming from the resulting damage to fish stocks and decline in water levels and water quality. However, caution should be applied as these projections are derived from a single climate scenario; other scenarios provide less consistent trends. More recent analysis of runoff from Caucasus Glaciers suggest a significant increase in the short-term (up to 2022) as melting intensifies, but near total loss of glaciers and glacial meltwater towards the end of the 21st century (Bliss et. al, 2014). A likely impact of the loss of Armenia's mountain glaciers is an increase in variability of water flows as glaciers typically act to smooth runoff over the year (Barnett, et. al, 2005). Water scarcity towards the end of summer (August, September) is likely to increase. Armenia has already experienced declines in annual precipitation and desertification has been documented around the nation, including in the Ararat Valley, an important agricultural production area (Ministry of Environment, 2020). More information is needed to understand the potential threat of a broader restructuring of the nation's ecosystems, particularly whether tipping points threaten the viability of current agricultural operations. The complexity of regional hydrological systems may mean climate change leads to unforeseen negative outcomes. For example, research suggests potential declines in water quality and safety for human consumption as a result of ongoing changes (Margaryan, 2017).

Water quality

Armenia's major environmental problems are: soil pollution from toxic chemicals such as DDT; deforestation resulting from the energy crisis of the 1990s, when citizens scavenged for firewood; pollution of the Hrazdan (Razdan) and Aras rivers; the draining of Lake Sevan, a result of its use as a source for hydropower, which threatens drinking water supplies; and the resumption of operations at Metsamor nuclear power plant, in spite of its location in a seismically active zone. Most of the drinking water is provided by groundwater, which has high organoleptic properties and is very pure. Due to the poor state of the water supply networks, however, the risk of water contamination is high. Due to the lack of liquid and lime chlorine and the electric power deficit, water in most cases is supplied without chlorination. In many places, sewage and drinking water supply networks are connected, and at present the sewage system is in an emergency situation: 63% of the network is more than 20 years old and 22% requires immediate renewal. According to data provided by the Ministry of Health, between 1984 and 1991 no infection outbreak episodes related to drinking water quality were recorded in Armenia. However, since 1992 such episodes have been periodically registered. During the 1999-2002 period, 18 outbreak episodes relating to water pollution were recorded, with a total of 5,690 diseased persons. In 2003, 21,839 incidents were recorded, 5,839 of which 26.7% occurred in Yerevan. Solonetzic soils, which are characterized by a tough, impermeable hardpan that may vary from 5 to 30 cm or more below the surface soils, are widespread. These soils are most exposed to the risk of irrigation-related salinization, mainly as a result of rising groundwater in the plains, where the majority of irrigated lands are located. In the Ararat plain, solonetzic soils cover about 10% of the area. In 2006, the part of the irrigated land that was salinized was 204 km^2, of which 151 km^2 was weakly salinized, 24 km^2 medium salinized, and 29 km^2 strongly salinized. (Water Action Hub, n.d.)

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<u>**Cyprus**</u>

Cyprus is an island country, located in the eastern end of the Mediterranean Sea, and the third largest island in the Mediterranean Sea, after the Italian islands of Sicily and Sardinia (both in terms of area and population). The total area of the island is 9,251 km^2. It measures 240 km long and 100 km wide at its widest point. It lies between latitudes 34° and 36° N, and longitudes 32° and 35° E. The population of Cyprus is estimated at over 1.2 million (2020). The country's economy is mostly supported by its services sector, followed by the manufacturing and agriculture sectors. Cyprus lies at the south-eastern end of the Mediterranean Sea and Europe, which is one of the most sensitive hot spots and most vulnerable regions in the world regarding climate change. This makes the country highly vulnerable to the impacts of climate change from significant increase in temperature resulting in increase in the frequency and intensity of droughts and hot weather conditions. (Climate Knowledge Portal World Bank, n.d.)

Map of Cyprus (World Atlas, n.d.)

Climate

Cyprus has an intense Mediterranean climate with the typical seasonal rhythm strongly marked in respect of temperature, rainfall, and weather, generally. Hot and dry summers last from mid-May to mid-October and mild, rainy, rather changeable, winters last from November to mid-March, separated by short autumn and spring seasons. The annual mean temperature for Cyprus varies from year to year, from 16.1°C to 19.7° C, with an average of 17.5°C. The mean annual precipitation varies from year to year and from place to place. The lowest mean annual precipitation for Cyprus was 213 mm in 1972-73 and the highest was 800 mm in 1968-69. The mean annual precipitation for the period 1961-90 is 503 mm. The wettest months are normally December, January and February and the driest are July, August and September. (Climate Knowledge Portal World Bank, n.d.)

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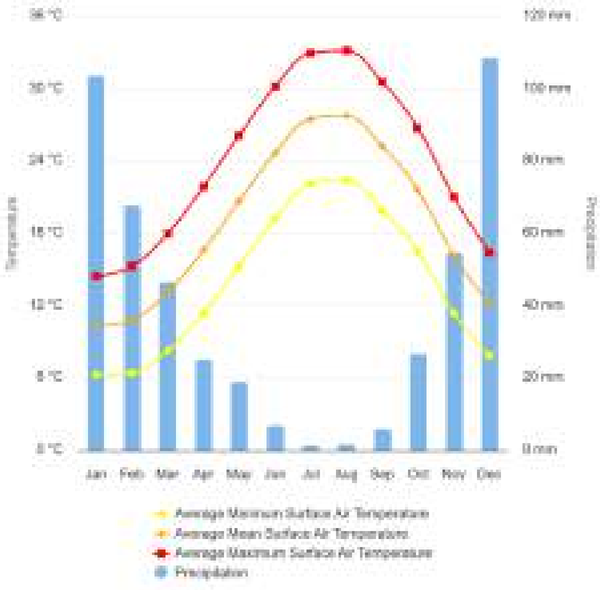
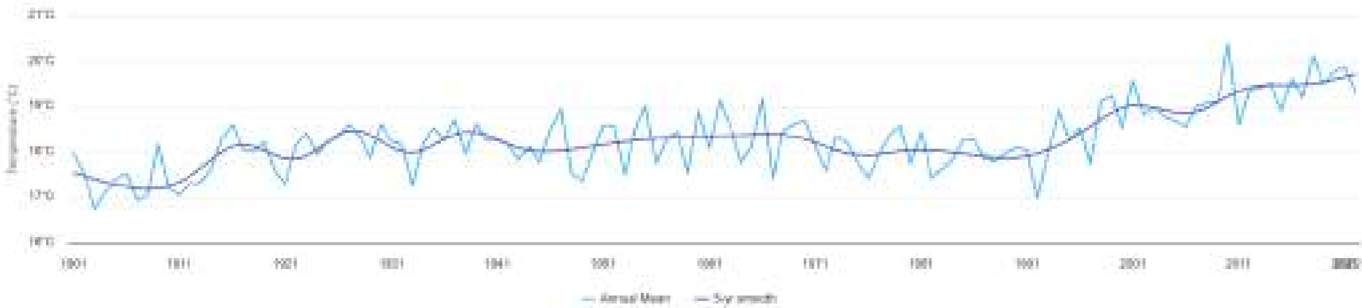


Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Cyprus. (Climate Knowledge Portal World Bank, n.d.)

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2020; Cyprus (Climate Knowledge Portal World Bank, n.d.)



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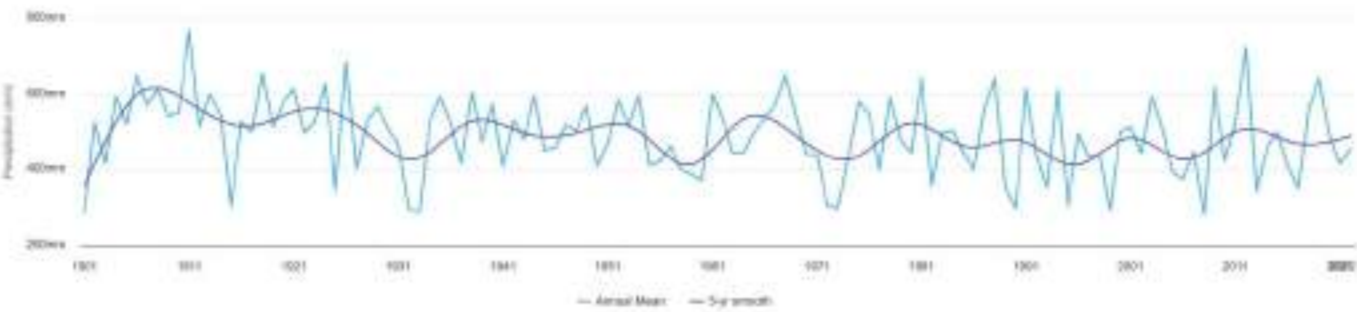

Observed Annual Percipitation of Cyprus for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

A water balance for the whole island, however, indicates 900 million m^3/year of renewable water resources. Surface runoff is estimated at about 830 million m^3/year. The natural aquifer recharge is estimated at 300 million m^3, of which about 70 million m^3 flows to the sea and 100 million m^3 emerges from springs. There are 14 main rivers, none of which provides perennial flow. The source of water for these rivers originates in the Troodos mountains. The main groundwater aquifers are the Western Mesaoria (Morphou), Kokkinochoria (south-eastern and eastern Mesaoria) and Akrotiri. Smaller aquifers exist in other parts of the country. In 1995, total dam capacity reached 299 million m^3 on the whole island, up from 6 million m^3 in 1961 and 64 million m^3 in 1974. New dams for storing water for irrigation are planned, particularly in Paphos province in the southwestern part of the island. Additional dams are also planned for Lefkosia province in the centre of the island, but a substantial quantity of this water will be diverted for domestic and industrial use and to compensate for the loss of water recharge downstream of the dams. (Water Action Hub, n.d.)

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The water resources of Cyprus are considered vulnerable to climate changes, since they are limited due to the semi-arid climate that characterizes this Mediterranean island. Freshwater availability depends almost entirely on rainfall which is highly variable with frequent prolonged periods of drought. The Republic of Cyprus in order to satisfy drinking water and irrigation demand, continue deliver a number of water works for the exploitation of the available freshwater resources (both surface and groundwater) and no-freshwater resources (sea water, recycled water). According to the standards of the International Commission of Large Dams, Cyprus is the first in Europe regarding the number of dams per square kilometre, having 108 dams and reservoirs with a combined storage capacity of 332 m^3. The water sector currently experiences both quantitative and qualitative pressures from several environmental and socio-economic activities and practices. In specific, the impact, vulnerability and adaptation assessment for water resources in Cyprus, regarding the observed climate changes in recent past, showed the following key vulnerabilities: i) Water availability for irrigation, ii) Frequent occurrence of droughts, iii) Groundwater quality, and iv) Water availability for domestic water supply. These impacts are expected to worsen in future period 2021–2050 as already projected by the PRECIS and ENSEMBLES regional climate models with respect to the control period 1960-1990. (Republic of Cyprus Ministry of Agriculture, Rural Development and Environment, 2018)

Water quality

Currently, some 40 million m^3 of wastewater is produced annually on the whole island. Only 16 million m^3 of this amount is treated, mainly in Leflkosia province, where the city of Nicosia is located. Nicosia has a city-wide sewage processing plant, part of which is not under government control. About 11 million m^3 is reused for irrigation purposes, mainly in the part of the island that is not under government control around the mentioned city. Only 1 million m^3/year is reused for the irrigation of hotel gardens and recreation areas in the government-controlled area. There are also other sewage plants in use, such as that located in Limassol or in Larnaca. (Water Action Hub, n.d.)

Surface water bodies in Cyprus are mainly the storage reservoirs with no inflows during the summer months. As a result there is no dilution and in combination with the high evapotranspiration rates, their quality will be deteriorated. In addition the increasing temperatures enhance eutrophication rates, stratification and low levels of dissolved oxygen. A trend in water quality deterioration is mainly observed in groundwater resources, due to the low recharge rate in combination with the low permeability of some sedimentary aquifers in Cyprus, which results in the dissolution of soluble salts and the increase in salinity. The rapid urbanization in various parts of Cyprus during the last 30 years, the uncontrolled waste discharge, the excessive use of fertilizers and pesticides, the overexploitation of many coastal aquifers gradually deteriorated the quality of Cyprus' groundwater. Republic of Cyprus Ministry of Agriculture, Rural Development and Environment. (2018).

Waterlogging, soil salinization and vector-borne diseases are not present in Cyprus. Contamination of groundwater, especially with fertilizers (particularly nitrates) in certain areas of the island where agriculture is intensively practiced, does, however, occur and is a cause of concern. There is also the problem of seawater intrusion in the main coastal aquifers. This situation requires close monitoring. One of the main water quality problems in Cyprus is water salinization owing to a combination of seawater intrusion, natural saline waters and anthropogenic sources such as agricultural return flows enriched with nitrates, pesticides and insecticide residues from agricultural activities. (Water Action Hub, n.d.)

Water quality problems in Cyprus are due to the presence of salts and pollution exacerbated by agriculture. High salt concentrations are becoming increasingly present in groundwater due to the over pumping and subsequent salt water intrusion into the aquifer. Recent studies have shown that reservoir water (surface water stored in dams) is becoming increasingly polluted with chlorinated pesticides, reaching levels that are higher than the permissible amounts set by the European Union. Approximately a quarter of the groundwater bodies in Cyprus are at risk due to excessive nitrate concentrations, from urbanisation (waste water in septic tanks and cesspools) and agricultural activities. Water from wells is, however, free of pesticide residues, although higher than acceptable levels of nitrates are common in areas that are intensively farmed. (Sofroniou & Bishop, 2014).

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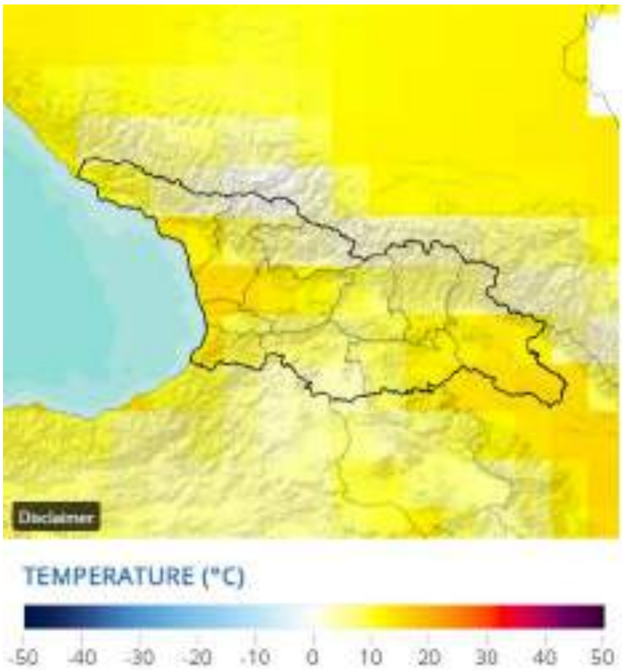
Georgia

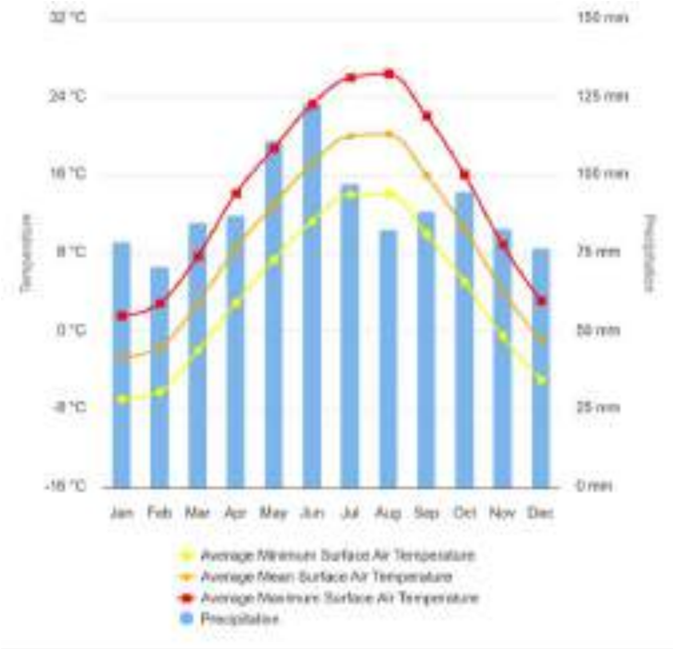
Georgia is situated in the south-eastern part of Europe, south to the Great Caucasus Range. Georgia is bordered by Russia to the north, by Armenia to the south, by Azerbaijan to the southeast, by Türkiye to the southwest and by the Black Sea to the west. Georgia covers a territory of 76,284 km^2, including the Autonomous Republic of Abkhazia and Tskhinvali Region and the territorial waters, of which the land area takes about 91%, and the water takes about 9%. Two third of country's territory is mountainous, with a complex relief. 54% of its territory is located at the altitude above 1000 m. The landscape of the country is quite varied with its mountains, plateaus, low-lands, glaciers, swamps and arid areas (semi-deserts), lakes and rivers. With regard of land use, 15.8% represents the cropland, 70.6% is covered by forests, shrubs and grasslands, and 13.6% is used for agriculture activities. Geographically Georgia is divided into two parts: East and West, naturally divided by the Likhi Range. By January 1, 2019 the population of Georgia was 3,723 thousand - 6,000 less than in 2018. 59% of the population is urban, and the rest 41% - rural. 1,171 thousand people live in Tbilisi, i.e. more than 30% of the total population. Population density is 65.1 persons per 1 km^2. Economic growth has been solid – averaging 5% per annum between 2005 and 2019 – and poverty (national measure) declined rapidly to 19.5% in 2019, almost half its 2007 rate, spurred by sound macroeconomic policies and improved governance. The country's economy is supported by its services, tourism, financial (banks), and construction sectors, a transition from industry and agriculture-based economy. (Climate Knowledge Portal World Bank, n.d.)

Map of Georgia (World Atlas, n.d.)

Climate

In the western part of Georgia, the climate is subtropical, while in the eastern part experiences a dry moderate continental climate. Annual precipitation in Georgia ranges from 400 to 4,500 mm. Due to its location at a relatively low latitude and moderate cloudiness, Georgia receives significant heat from the sun. The average annual duration of bright sunshine ranges from 1,350 to 2,520 hours. (Climate Knowledge Portal World Bank, n.d.)





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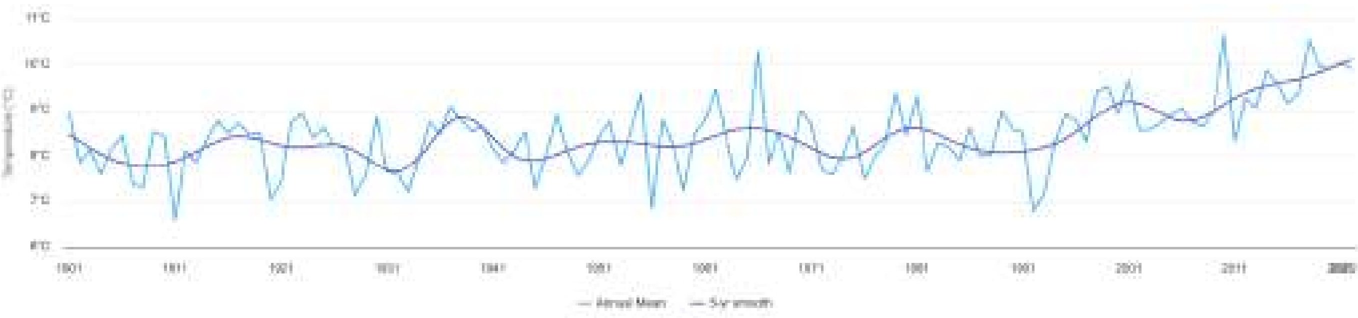

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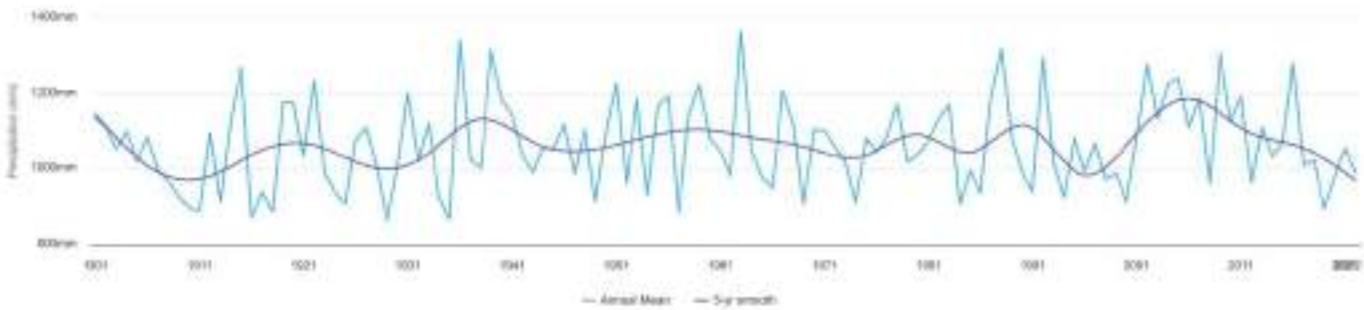
Observed Climatology of Percipitation 1991-2020; Georgia (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Percipitation of Georgia for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

Georgia can be divided into two main river basin groups: The Black Sea basin, in the west of the country. The main rivers are, from north to south, the Inguri, the Rioni and the Chorokhi. The main stream of the Chorokhi rises in Turkey (the Corub River). The Caspian Sea basin, in the east of the country. The main rivers are, from north to south: the Terek and the Andiyskoye, which rise in the north of the country and flow northeast to the Russian Federation before entering the Caspian Sea; the Alazani, the Lori and the Kura, which rise in Georgia and flow into Azerbaijan in Lake Adzhinour, before flowing southeast in Azerbaijan and then entering the Caspian Sea. Two tributaries of the Kura River rise in Turkey: the Mtkvari, and the Potskhovi. The Debet River, a southern tributary of the Kura River, from Armenia. Georgia has 25,075 rivers exist with a total length of 54,768 km; 99.4% of them are small rivers with a total length of less than 25 km. Hydrological studies have been made of 555 rivers of the Black Sea Basin and 528 rivers of the Caspian Sea Basin. More than 17,000 rivers (total length 32,574 km) belong to the Black Sea Basin. There are about 43 dams in Georgia, 35 of which are in the east and 8 in the west; their total reservoir capacity is estimated at about 3.4 km^3. The water is primarily used for irrigation and hydropower generation and less for water supply. The largest dam, for hydropower, is the Inguri dam, with a reservoir capacity of 1.092 km^3. In 1995, hydropower supplied 89% of electricity. Some 31 dams have been built for irrigation purposes; they have a total reservoir capacity of 1 km^3, of which 782 million m³ are active. The three largest irrigation reservoirs are: the Sioni reservoir (325 million m^3) on the Lori River, the Tbilisi reservoir (308 million m^3) on the Kura River and the Dalimta reservoir (180 million m^3) on the Lori River. (Water Action Hub, n.d.)

Water quality and water supply

Georgia is a country with abundant fresh water resources, but the current situation of the water supply is extremely complicated. This is largely due to anthropogenic contamination, deficit of drinking water and low sanitary standards of the water supply system. About 60% of existing water pipelines are depreciated. Their sanitary and technical conditions are unsatisfactory. Due to water network damages, large quantities of water are lost. According to data for 1999, such losses amounted to 40% of the overall quantity of water supplied to households. Due to the degradation of the water supply and sewerage infrastructure, the quality of drinking water often does not comply with human health and safety standards. Some 38% of the water pipeline system of the cities and regions belongs in the high-risk water pipeline category, in which the microbiological contamination index is high. The poor quality of water has resulted in several outbreaks of infectious intestinal diseases and epidemics. In eastern Georgia there is a salinization problem relating to irrigation. Currently, 592.2 km^2 are severely salinized and 543.4 km^2 are moderately salinized. The poor quality of management and infrastructure of the irrigation systems has added to these problems during the past decade. The main sources of risk from pollution are municipal sewage effluent and some hot-spots of industrial and mining pollution. Municipal wastewater is mostly not treated at all but is discharged directly to the rivers or to the Black Sea. Only the Tbilisi wastewater treatment plant provides mechanical treatment of effluent. Although mine process water is recirculated, it can spill accidentally, especially during heavy rain, carrying metal pollution to the rivers. As most industry of the USSR era has declined, the main pollution risk will come from newly emerging or revived industries if they are established without proper planning controls. River pollution from municipal waste landfills that are poorly designed is also important in that it reduces the recreational amenity value of the river. (Water Action Hub, n.d.)

Georgia is rich in freshwater; however, these resources are unevenly distributed (heavily concentrated in western regions) and issues in the water supply system mean that people in rural areas rely on wells and boreholes for their water. This increases their vulnerability to potential reductions in groundwater and drought periods. Rivers that are fed by glaciers and snow, such as the Khrami-Debed and Alazani, are projected to see reduced flow levels of between 30% and 55% by the end of the 21st century, posing a threat to an important source of water supply. This issue is projected to be more severe in spring and summer months and indeed will drive significant shifts in regional hydrological regimes. The negative impact of this reduction in river flow could be exacerbated by increases in average temperatures and heat wave probability, leading to higher agricultural demand for river-fed irrigation. Over the short term, the ongoing glacial melt could lead to increases in runoff. (World Bank, 2021)

Water from wells in Georgia is generally safe for consumption without treatment. Some waters, however, may contain disease-causing organisms that make them unsafe to drink. Well waters may also contain large amounts of minerals, making them too “hard” for uses such as laundering, bathing or cooking. Some contaminants may cause human health hazards and others can stain clothing and fixtures, cause objectionable tastes and odors, or corrode pipes and other system components. Surface water sources, such as springs and cisterns, are seldom used for drinking water. They are almost always contaminated with pathogenic microorganisms; therefore, surface water should always be treated before being consumed. (University of Georgia Extension, 2023)

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Greece

Greece has a total area of 131.957 km^2 and occupies the southernmost extension of the Balkan Peninsula. The mainland accounts for 80% of the land area, with the remaining 20% divided among nearly 3000 islands. The Greek landscape, with its extensive coastline, exceeding 15,000 km in length, is closely linked with the sea, since only a small region in the northwest is further than 80 km from the sea. Approximately 25% of it is lowland, particularly the coastal plains along the seashore of the country. Greece is a mountainous country two-third of which are largely covered by mountains of medium height. Forest land covers 26.2% of the total area of the country. Other 40.3% of the total area of the country is covered by grassland, rangeland, and pasture with vegetation. Agricultural land accounts for 25.1% of the total area. Settlements and transportation infrastructure account for 4.1% of the total area. Finally, wetlands, land that is covered or saturated by water for all or the greatest part of the year, and other land, areas that do not fall into any of other land-use categories (e.g. rocky areas, bare soil, mine and quarry land), account for 2.3% and 2.1%, respectively. Greece has a very long coastline, exceeding 15,000 km. (Climate Knowledge Portal World Bank, n.d.)

Map of Greece (World Atlas, n.d.)

Climate

Greece has a Mediterranean climate, with mild and wet winters in the southern lowland and island regions and cold winters with strong snowfalls in the mountainous areas in the central and northern regions and hot, dry summers. The mean temperature during summer (April to September) is approximately 24°C in Athens and southern Greece, while lower in the north. Generally, temperatures are higher in the southern part of the country. Except for a few thunderstorms, rainfall is rare from June to August, where sunny and dry days are mainly observed. The dry, hot weather is often relieved by a system of seasonal breezes. The mean annual temperature for the period 2001 – 2015, as measured at selected meteorological stations of the country, is higher in most of the stations compared to the mean

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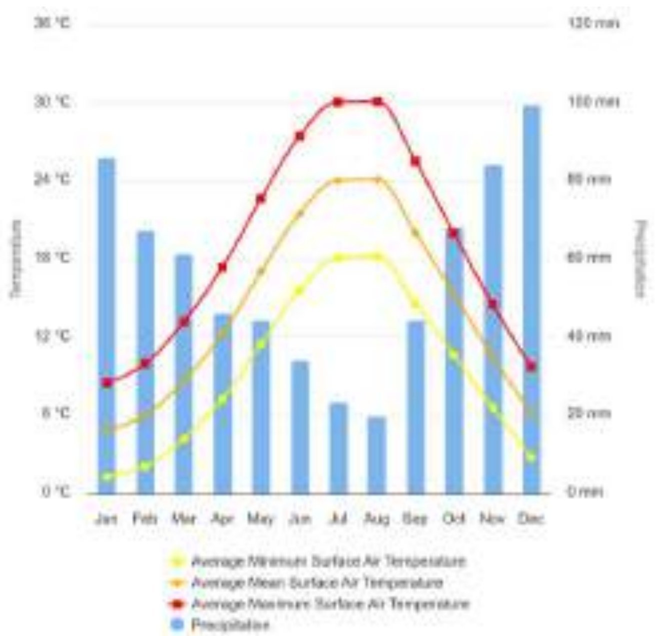
annual temperature of the period 1991 – 2000 while the mean annual temperature for the period 1991 – 2000 is higher compared to these of the period 1961 – 1990. (Climate Knowledge Portal World Bank, n.d.)



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Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2020; Greece (Climate Knowledge Portal World Bank, n.d.)

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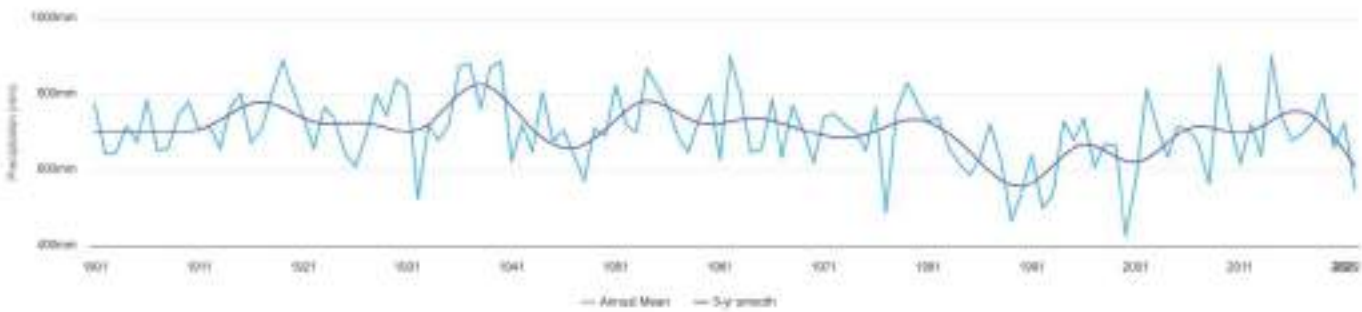

Observed Annual Percipitation of Greece for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

Greece has a long-term average annual precipitation of 652 mm/year. The long-term average of annual renewable water resources is 74,250 million m³/year of which 78% are considered internal water resources (57,915 million m³) and around 22% are considered external water resources (16,335 million m³). As at 2009 the total dam (reservoir) capacity was 11,770 million m³. However, in Greece, freshwater issues are related to quantity rather than quality. Greece has an uneven spatial mean annual and seasonal rainfall distribution, resulting in rather small catchment areas, small lakes and relatively small rivers, distributed throughout the country. In addition, the catchments in Greece are marked by high spatial differences in morphologic, climatic, hydrographical, petro-graphic and vegetative features. The hydro-geological conditions differ significantly with geographical latitude and longitude. The main aquifers have been formed either from depositions in layers of sand, gravel and shingle or from chalky rocks that become karst due to the flow of water through cracks that were shaped by tectonic movements. It should be emphasised that groundwater

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that flows in aquifers of the first category can be utilised more easily and therefore has already been exploited intensively. On the other hand, karst groundwater was not abstracted until 1968 and there is still the possibility of further utilisation. The overabstraction/exploitation of groundwater resources has in many instances led to the decline of the water table as well as to the deterioration of water quality, primarily through saltwater intrusion in coastal areas. (Water Action Hub, n.d.)

Water quality

Until the middle of the last century, surface freshwater in Greece mainly followed the slow rhythm of natural changes, with little or no influence from human activities. However, from the 1960s, a number of water bodies situated either in the vicinity of urban areas or in regions with increased agricultural and industrial activity, showed signs of pollution. The phenomena associated with pollution have gradually grown and have recently started to influence smaller and previously unaffected water bodies. Urbanization has been a strong driver of land use change over the post-war period in Greece. Eight million people live in urban areas. Urbanization exacerbates some local environmental problems, such as air and noise pollution, traffic congestion and urban waste disposal. Inappropriate waste disposal and management practices may lead to the degradation of surface and ground waters, air pollution and forest fires. In addition, agricultural production has been intensified in productive areas and, in combination with bad land management, can be a threat for the soil. The implementation of the revised Common Agriculture Policy by the year 2011 and the introduction of good agricultural practices, are expected to improve the soil condition in Greece. The catchments in Greece are marked by high spatial differences in morphologic, climatic, hydrographic, petrographic and vegetative features and variability in pollution impact. As a result, river and stream habitat, hydrochemical regime and biocommunity structure, vary considerably along their courses. In addition, research on ecological quality assessment is limited and geographically restricted, and classification systems are absent. Hence, the assessment of the ecological quality of Greek rivers is a complex task and needs a special approach, since an optimal 'ecological quality assessment' can only be achieved through regional adaptations. The nitrate concentrations in groundwater bodies generally reflect the relative importance and intensity of agricultural activities above them. Mean nitrate concentrations in groundwaters are above the background levels (10 mg/l NO_3), but well below the parametric value of 50 mg/l NO_3. Between 2000 and 2007, the annual average nitrate concentrations in Greek rivers decreased by approximately -43.5% (from 2.67 to 1.51 mg N/l), reflecting the effect of measures to reduce agricultural inputs of nitrate. Nitrate levels in lakes are generally much lower than in rivers and vary between 0.27 mg N/l and 0.44 mg N/l over the period 2000 to 2007. The number of monitoring stations in lakes increased from 13 stations in 2000 to 26 stations in 2007. Phosphorus concentrations in Greek rivers and lakes have generally low levels over the period 2000 to 2007. In Greece, existing policies are effective in reducing loading discharges of nutrients and organics. Much progress was made during the period 1980 to 2008 in equipping Greece with sewerage and wastewater treatment systems, thus satisfying the objectives of the EU Urban Waste Water Directive 91/271/EC (UWWD). Water quality and safe sanitation are considered to be of a high priority and measures have been taken. There is a particular challenge in fully covering the water supply needs of the small islands and remote mountainous villages. In order to comply with the UWWD, by the end of 2008, 91% of the population is expected to have wastewater treatment plants meeting the requirements of the directive, and 88% of this population will be served by sewerage systems. There are 290 treatment plants in Greece, with 242 municipal wastewater treatment plants falling under the UWWD, and smaller plants making up the remainder. The authorities responsible for the operation of most treatment plants are the Municipal Services for Water Supply, but in cases of the Psytalia (Athens) and Thessaloniki treatment plants, the responsible authorities are EYDAP and DEYATH respectively. (Water Action Hub, n.d.)

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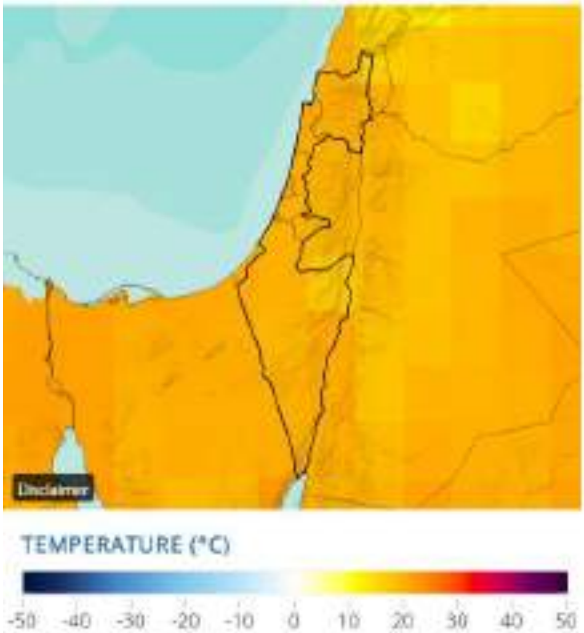
Israel

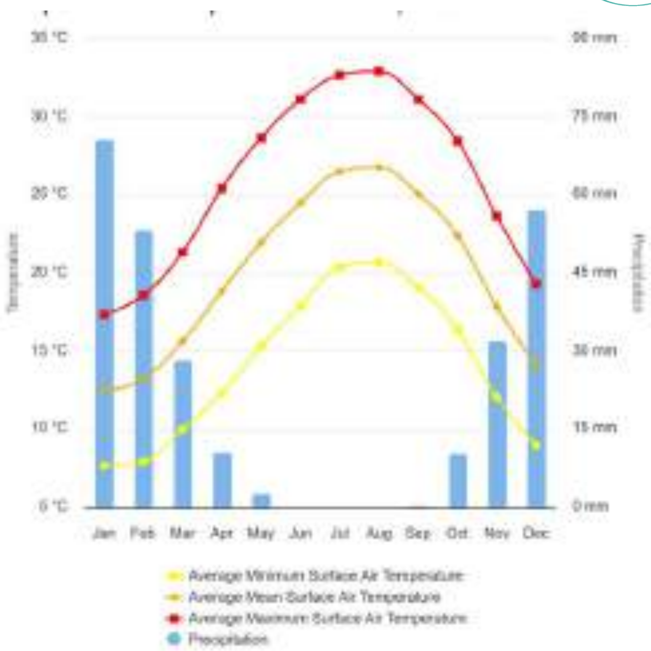
The State of Israel is located on the southwest tip of the Asian continent, in the eastern basin of the Mediterranean Sea. Total area of the country is 22,072 km^2, 97.6% of which is land and 2.4% of which is marine (Sea of Galilee and the Dead Sea). The most crucial component of Israel's climate is the rainfall regime. Changes in the rainfall regime, including annual quantity, number of rain spells, seasonal distribution, intensity and timing, all have major impacts on the country's water resources. Israel's vast range of ecosystems, from the humid Mediterranean coast to the arid desert, hosts a range of climate vulnerabilities and challenges. As temperatures increase, conditions become drier and storms become stronger, critical resources will become more vulnerable. (Climate Knowledge Portal World Bank, n.d.)

Map of Israel (World Atlas, n.d.)

Climate

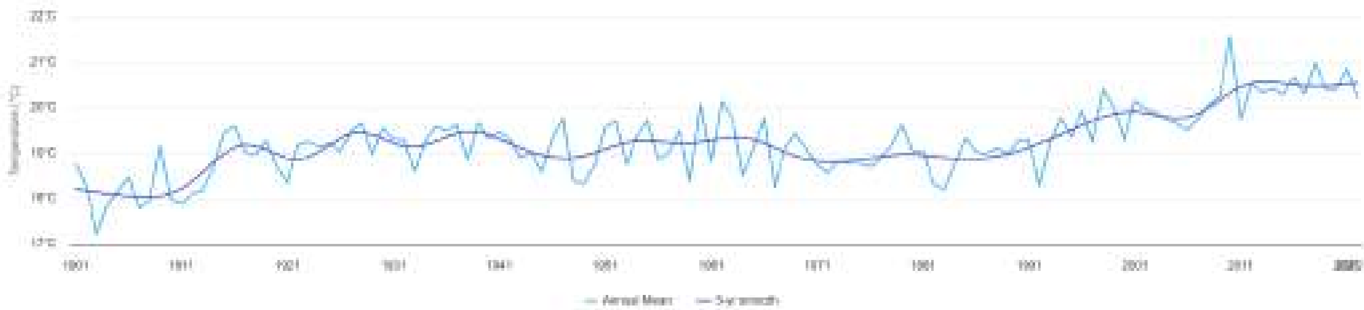
Israel lies in a transition zone between the hot and arid southern part of West Asia and the relatively cooler and wetter northern Mediterranean region. The northern part of Israel is characterized by a Mediterranean climate, while the southern part is arid, with a narrow, semi-arid strip in between. Israel's climate is characterized by hot summers and mild winters. Rainfall varies significantly across the country and from year to year. (Climate Knowledge Portal World Bank, n.d.)





Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Israel. (Climate Knowledge Portal World Bank, n.d.)

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2020; Israel. (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature of Israel for 1901-2022. (Climate Knowledge Portal World Bank, n.d.)

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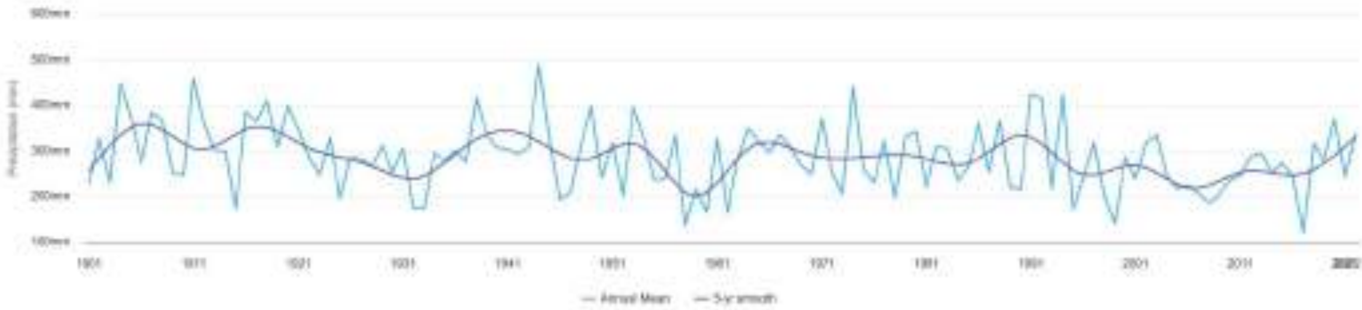
Observed Climatology of Percipitation 1991-2020; Israel. (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Percipitation of Israel for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

The only river in Israel is the Jordan. The main sources of fresh water in Israel include: Lake Kinneret or Lake Tiberias (the Sea of Galilee), which divides the upper and lower portions of the Jordan River system. It has traditionally provided about a third of the country’s domestic, agricultural and industrial water requirements. The total average annual inflow of water into Lake Tiberias amounts to 1km^3, of which around 250 million m^3 serve consumers in the region, about 450 million m^3 are withdrawn from the lake to serve consumers throughout the country by means of the National Water Carrier and about 300 million m^3 are lost by evaporation. The Coastal Aquifer is a sandstone aquifer which extends along 120 km of the Mediterranean coastline. It is naturally recharged by precipitation and artificially recharged by water from the National Water Carrier, effluents and excess irrigation water percolating from agricultural, industrial and domestic land uses as well as from streams and wadis. It has a mean annual recharge of 250 million m^3 in addition to 50 million m^3 of agricultural drainage water. The Mountain Aquifer (Yarkon-Taninim) is a limestone aquifer which underlies the foothills in the centre of the country. The basin is comprised of three subaquifers: the Western Basin, known as the Yarkon Taninim Aquifer, flows north and westward and discharges in the Taninim Springs on the Mediterranean coast while the Northeastern and Eastern Basins discharge in the Beit Shean Springs and the Jordan Rift Valley and Dead Sea. The Yarkon Taninim Aquifer is regenerated by precipitation with an average of annual renewable recharges of about 350 million m^3. Relatively smaller aquifers are located in Western Galilee, Eastern Galilee, the Jordan Rift, and the Arava Valley. Total internal renewable water resources are estimated at 750 million m^3/year. About 250 million m^3 is surface water, 500 million m^3 groundwater and the overlap between surface water and groundwater is considered to be negligible. Surface water entering the country is estimated at 305 million m^3/year, of which 160 million m^3 are from Lebanon (including 138 million m^3 from Hasbani), 125 million m^3 from the Syrian Arab Republic, and 20 million m^3 from the West Bank. Groundwater entering the country is estimated at 725 million m^3/year, of which 325 million m^3 are from the West Bank, 250 million m^3 from the Syrian Arab Republic and 150 million m^3 from Lebanon. The total renewable water resources are thus 1,780 million m^3/year, of which 92% is considered to be exploitable. About 25 million m^3/year of groundwater flow from the country to the Gaza Strip. Israel's national water supply company, has built and operated small and medium-size desalination facilities since the 1960s. (Water Action Hub, n.d.)

Water quality

The quality of supplied water in Israel varies from very low salinity water (10 mg/l of chlorides) from the Upper Jordan River, 200 mg/l from the Kinneret, and more than 1,500 mg/l from groundwater sources in the south. Groundwater exploitation is controlled to prevent seawater intrusion to the Coastal Aquifer and movement of saline water bodies within the Karstic Limestone Aquifer. Israel's current water crisis is the result of both natural conditions (climate, geography and hydrology) and human activity. Overpumping from aquifers to meet growing demands has led to the infiltration of seawater and salinity, the impoundment of springs has dried up perennial and ephemeral streams, and domestic, industrial and agricultural practices have contaminated water sources. The quality of the country's main water sources has been increasingly endangered by pollutant discharges from different sectors: The Coastal Aquifer is seriously threatened by chemical and microbial pollutants, salinization, nitrates, heavy metals, fuels and toxic organic compounds. According to the most recent report of the Hydrological Service, about 15% of the total amount of water pumped from the Coastal Aquifer does not comply with existing drinking water standards for chloride and nitrate concentrations. Average chloride concentrations in the coastal aquifer are increasing at an average rate of 2 mg/l per year, reaching an average of 195 mg/l in 2002/03. Chloride concentrations below 250 mg/l and nitrate concentrations under 45 mg/l exist in only 50% of the water which is drawn from wells in the coastal basin. These concentrations are unsuitable for unrestricted agricultural irrigation. Nitrate concentrations in the Coastal Aquifer have increased considerably due to intensive use of fertilizers in agriculture and use of treated effluents for irrigation. Since 1950, average nitrate concentrations have increased from 30 mg/l to 63 mg/l today, with an annual rate of increase of about 0.6 mg/l. Concentrations exceeding 70 mg/l were measured in traditional agricultural areas in the centre of the country. Because of the deterioration in both the quantity and quality of the water in the Coastal Aquifer, the Yarkon-Taninim Aquifer is becoming a main supplier of drinking water in the country. Water levels in this aquifer have decreased while a gradual increase in chlorides has been noted over the years. This deep limestone aquifer is especially prone to contamination due to its karstic nature and the quick transit of pollutants through it. Overexploitation may lead to a rapid rate of saline water infiltration from surrounding saline water sources. Due to the continuous drop in water levels in Lake Tiberias since 1996, regulations have lowered the minimum "red line" from 213 m below sea level to minus 215.5 m in 2001. The risks associated with reduced water levels are enormous: ecosystem instability and deterioration of water quality, damage to nature and landscape assets, receding shorelines and adverse impacts on tourism and recreation. Salinity in the lake has been alleviated by diverting several major saline inputs at the northwest shore of the lake into a "salt water canal" leading to the southern Jordan River. This canal removes about 70,000 tonnes of salt (and 20 million m^3 of water) from the lake each year. The salt water canal is also used to remove treated sewage from Tiberias and other local authorities along the western shoreline away from Lake Tiberias and into the Lower Jordan River. In the catchment area, a concerted effort has been made to lower the nutrient load by changing agricultural and irrigation practices, by cutting back the acreage of commercial fishponds and by introducing new management techniques. Sewage treatment plants were improved and a new drainage network that recycles most of the polluted water within the watershed was constructed. Around the lake, public and private beaches and recreation areas with appropriate sanitary facilities were developed. Pollution and sewage from settlements and fishponds near the shores were treated and diverted from the lake. (Water Action Hub, n.d.)

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Italy

Italy is located in the Southern part of Europe and includes the Italian peninsula, that from the Alps stretches into the Mediterranean Sea, and several islands including Sicily (the largest in the Mediterranean Sea) and Sardinia. The Alps mountain range is the Italian natural northern border which separates Italy from the rest of Europe. The total national area is 301,340 km^2, about 40% of the total national area is mountainous. The driving sector of the national economy is the service sector. The national population is expected to reach over 60 million by 2030. Italy is located in an area identified as particularly vulnerable to climate change. Climate observations already confirm an increase of the average temperature as well as an upward trend in extreme temperatures. Italy is prone to natural hazards and climate change is expected to increase its vulnerability to climate-related hazards over the next decades. (Climate Knowledge Portal World Bank, n.d.)

Map of Italy (World Atlas, n.d.)

Climate

The Italian peninsula lies between latitudes 47°C and 35° N and longitudes 6° and 18° E, it is nearly in the middle of the temperate area of the boreal hemisphere. Being Italy surrounded by sea, Italy's climate is temperate Mediterranean. Italy's climate is formally divided in four types, characterized by specific features: Alpine climate, dominant in Alps and northern and central Apennines, characterized by night and winter low temperatures and moist summer; Mediterranean climate, in the island and in the southern Italy, characterized by mild temperatures and moist winter;

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Peninsular climate, peculiar of the central part of the peninsula, characterized by mild temperatures along the coast and in the prompt hinterland (in the middle where the altitude is high there is an alpine climate), moist in spring and autumn; and Po valley climate, with low temperatures in the winter, high in the summer, moist in the spring and autumn. Climate Knowledge Portal World Bank, n.d.)

Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Italy (Climate Knowledge Portal World Bank, n.d.)

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2020; Italy (Climate Knowledge Portal World Bank, n.d.)

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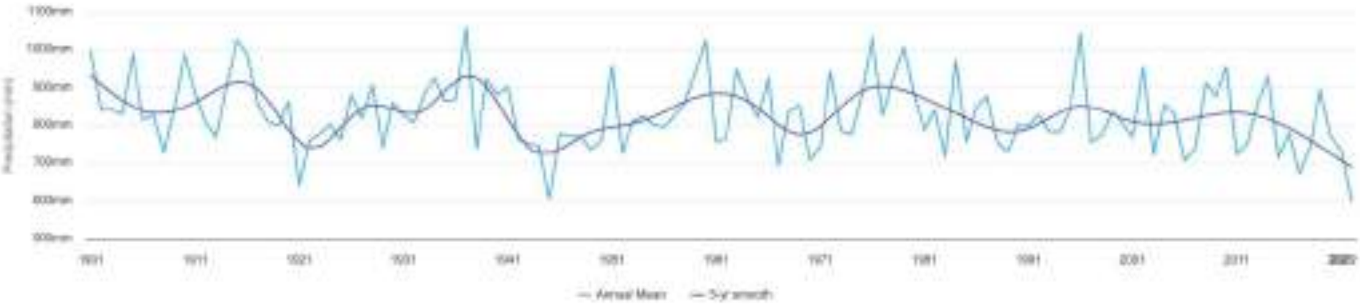

Observed Annual Percipitation of Italy for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

In Italy 100% of the urban population and 97% of the rural population have access to water. 20% of the bathing water does not satisfy bathing water standards. 70% of the population has access to sanitation. Water supply is becoming a social and economic emergency in Apulia, Basilicata, Sicily and Sardinia, primarily because of increasing water demand and lack of management practices. Further associated decreases in mean precipitation could aggravate this situation. Water stress might increase by 25% in this century. In Italy, the total meteoric inflow is of about 300 billion m^3/year. The highest percentage of these precipitations, a little more than 40%, is concentrated in the northern regions, 22% in the central ones, 24% in the southern regions and just 12% in the two largest islands, i.e. Sicily and Sardinia. The water resource availability, however, is estimated to be only 58 billion m^3/year, 72% of which derivable from surface resources (springs, rivers, lakes), while 28% from underground resources (water tables close to the surface). Almost 53% of the utilizable surface resources are localized in northern Italy, 19% in central Italy, 21% in southern

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Italy, and 7% in the two largest islands. Moreover, about 70% of the underground resources is localized in the large flood plains of northern Italy. Not many underground resources are utilizable in southern Italy, being confined in the short stretches of coastal plains and in a few inner areas. These data confirm the uneven distribution between northern and southern parts of the country and the reduction trend caused by the concurrent decrease in precipitation and increase in evapotranspiration and water utilization. (Climate Change Post, n.d.)

The expected impacts of climate change on water resources across southern European regions include further reductions in quantity, quality and availability, with increasing frequency and intensity of droughts, especially in summer. In particular, an increasing frequency and severity of river flow droughts could occur, with annual river flow decline and possible summer water flows reduction by up to 80%. Groundwater recharge shows a declining trend, with consequent shrinking of fresh groundwater resources, especially in coastal areas. In many parts of Italy, particularly in the south, it has become ever more difficult to meet demand for water. Wastewater reuse could represent a viable solution to meet water demand. Increased demand on water resources from new and diversified users is probably the main cause of reduced water availability in the northern Italy main basins. This reduction cannot be justified only on the basis of precipitation data that, especially in northern Italy, show a scarcely significant trend. In particular, with reference to water stress, Italy might experience: water stress increase by 25% in the present century, with a growing demand for irrigation water; socio-economic emergency concerning safe water supply in several regions, such as Puglia, Basilicata, Sicilia and Sardegna, primarily because of increasing water demand and lack of management practices, aggravated by further decreases in mean precipitation; reduced availability of water resources affecting drinking water supply, water supply for irrigation and for hydropower generation in the Po river valley; increased soil dryness and increased frequency of droughts in the areas of plains; water quality depletion; increased seasonal water deficit due to significant pressures of summer tourism peaks on already scarce water resources, especially in small Mediterranean islands, which could become a major constraint to touristic supply in the future; intensification of conflicts among multiple uses of water resources; navigation of lakes and rivers impaired by a reduction of precipitation and water levels. (Climate Change Post, n.d.)

Water quality

According to Frollini et al. (2021), in Italy, 57.7% (by area) of groundwater bodies were classified in good chemical status, 34.4% in poor status and 7.9% still have not been classified (data available until 2015, ISPRA, 2017). The chemical parameters that cause the poor chemical status are mainly not only inorganic compounds (such as nitrate, sulphate, fluoride, chloride, boron, metals) but also chlorinated compounds, aromatic compounds and pesticides. Due to the current short length of the chemical time series, the assessment of significant upward trends in Italy will be available only at the end of the current RBMP in 2021 (ISPRA, 2017).

In Italy, urban waste water is treated in 3,691 plants across the country before it is discharged. In Italy 56% of sewage is treated in line of EU legislation. (Water Europe, n.d.)

Despite the efforts made in the last century to counteract the nutrient enrichment from diffuse and point-sources, the excess of nitrogen and phosphorous is among the main causes of degradation of European rivers. In this context, determining natural background concentrations of nutrients in rivers is crucial for a correct definition of their ecological status. In the most anthropized regions, this is a difficult task. Nitrate concentrations varied from 0.01 mg N/l to more than 5 mg N/l. Ammonia and total phosphorous varied between 0.001 and 0.12 mg/l. Observed nutrient levels, although in line with those identified for reference sites in other countries, largely exceed the ranges reported for natural basins. Atmospheric deposition of inorganic N and artificial and/or high-impact agricultural land use are the major factors determining differences in nutrient concentration. (Erba et al., 2022).

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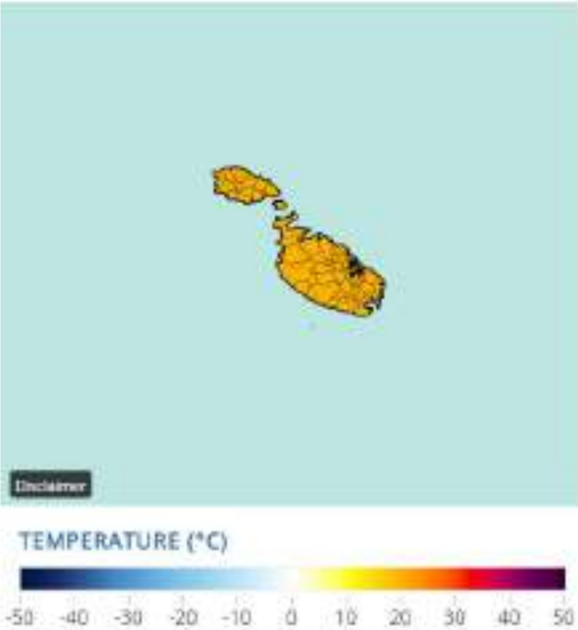
Malta

The Maltese archipelago consists of six islands namely Malta, Gozo, Comino, Cominotto, Filfla and St. Paul's Islands. The latter three are uninhabited. The Archipelago is located in the center of the Mediterranean Sea and the main islands Malta, Gozo and Comino cover a total land area of approximately 320 km^2 and 140 km of coastline. Total population amounted to over 440,000 in 2020. In spite of the lack of natural resources except for temperate climate, and historical and landscape features, over the past three decades the Maltese economy has transformed itself into a developed economy that is competing in the international market. The agriculture and fishing sector is relatively small, at around 2.5% of GDP, and in long term decline. This reflects mainly the unattractiveness for younger people to pursue an agricultural career because of the unsuitability of Maltese land and sea territory to allow for relatively large undertakings where new technology can be competitively applied. Industry and construction accounted for over a quarter of Maltese GDP up to 2003. However, as from 2004, the relative contribution of these sectors started to decline due to the expansion of the services sector. Service activities include distributive trades, financial services, transport, communication, and personal services. Taken together, services activities accounted for more than three quarters of the GDP since 2006. Land is scarce and its diminution or impoverishment arising out of climate change could have significant effects. The Maltese economy is highly dependent on foreign trade, services and tourism. The climate of the Maltese Archipelago is typically Mediterranean, with distinct winter and summer season i.e. mild, rainy winters and dry, hot summers. (Climate Knowledge Portal World Bank, n.d.)

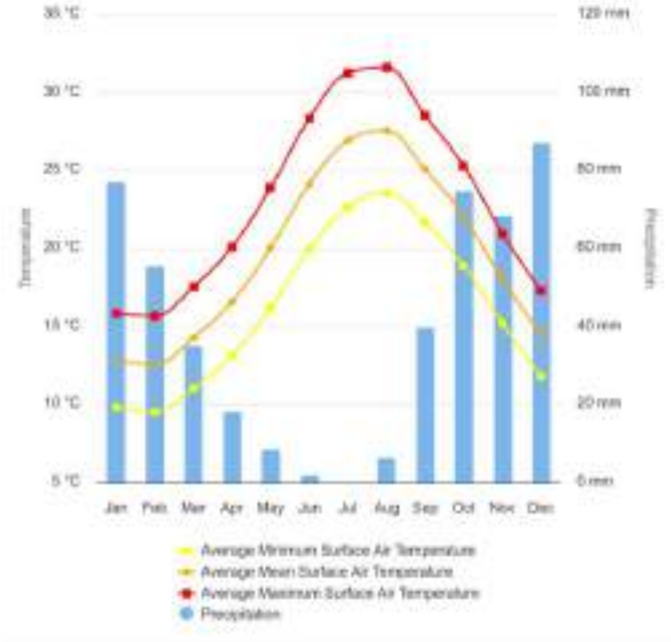
Map of Malta (World Atlas, n.d.)

Climate

The climate of the Maltese Islands can be described as typically Mediterranean, with hot, dry summers and relatively mild winters. (Climate Knowledge Portal World Bank, n.d.)



Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Malta. (Climate Knowledge Portal World Bank, n.d.)



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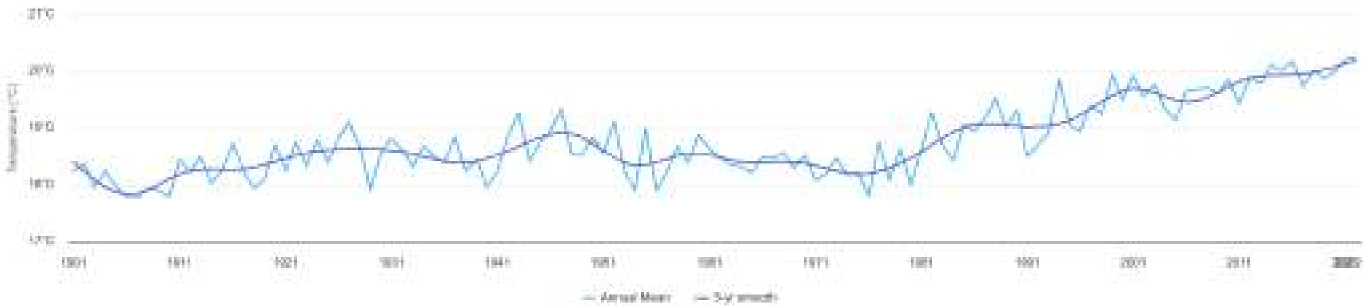

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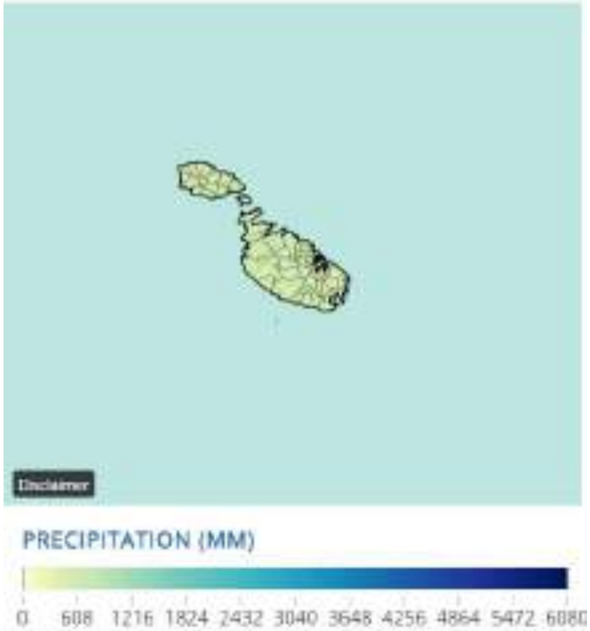

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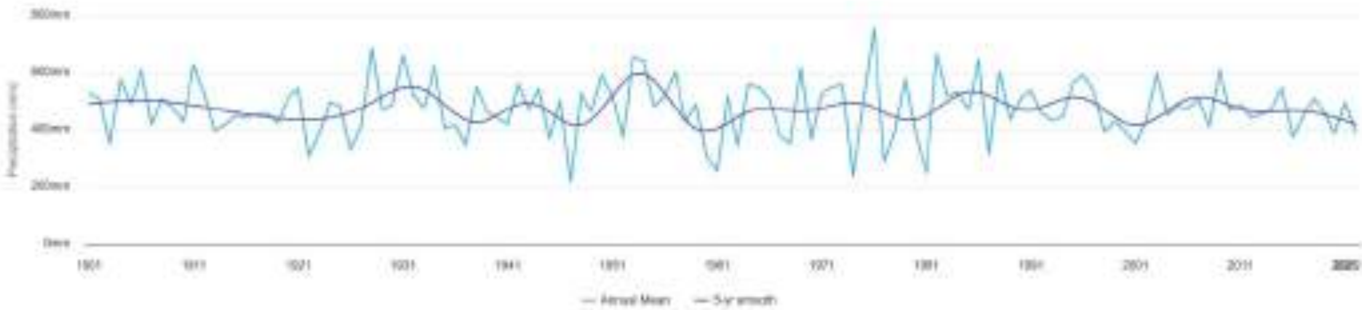

Observed Annual Percipitation of Malta for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

Despite the relatively low rainfall and the arid appearance of the Maltese Islands, local catchment characteristics are very favourable for the storage of rainwater and the hydrological cycle provides a generous supply of freshwater which undoubtedly contributed to the early settlement of the inhabitants. Total surface water resources are estimated at 0.5 million m^3/year. Malta tilts gently to the east giving rise to a topography that is high along the western shores and gently slopes down to sea level along the eastern shores. This implies that the surface drainage lines cross the entire width of the island from their source close to the western shore before reaching the sea on the east. This favourable topography, combined with the good water storage capacity of the soil, excellent infiltration characteristics and effective runoff interception by numerous dams and cisterns, gives the surface water maximum time to seep into the ground and thus minimizes runoff losses to the sea. A greater amount of surface runoff, however, is lost from urban areas via sewers or directly to the sea especially in coastal towns and villages. The Maltese Islands are divided into two main units by the Victoria Lines fault that crosses the northern part of the island of Malta from west to east. North of this fault, Malta is broken up into a number of horsts and grabens by less pronounced faults. Drainage is parallel to the general strike of the horst-graben system and the few intermittent streams flow into the bays to the northeast. The second morphologic unit lies south of the Victoria Lines fault, where two main drainage systems are found. The main one converges into the Valletta basin by a system of east or northeast-trending streams, while the second one converges into Marsaxlokk bay to the southeast. (Water Action Hub, n.d.)

The renewable groundwater potential on the Maltese Islands is estimated as being approximately 40 million m^3/year. In order not to deplete the storage capacity of the main aquifer without causing salt water intrusion, only 15 million

m^3/year of groundwater would be potentially extractable. Based on the 1995 figures of the Water Services Corporation, however, 19.75 million m^3/year were extracted from 13 pumping stations, approximately 160 boreholes in Malta and Gozo, and about 2,800 registered private wells (the latter extracting an estimated total of 2.44 million m^3/year). This means that groundwater depletion does in fact take place. Moreover, there is significant extraction from illegal and unregistered wells (probably up to 2.97 million m^3/year), leading to a total groundwater extraction of 22.72 million m^3/year. Most runoff occurs after heavy torrential rain. This is the only time when surface water flows, for a few days at most, along the beds of the major valleys. To retain this storm discharge, a large number of small dams have been constructed across the drainage lines. They also serve the purpose of reducing the rate of soil erosion. Open reservoirs have been constructed along recently made roads to minimize runoff. Total dam capacity is estimated at 154,000 m^3. (Water Action Hub, n.d.)

Water quality

At present 31.4 million m^3/year of desalinated water are being produced from four sea water Reverse Osmosis Plants and one brackish water Reverse Osmosis Plant, but this is a rather expensive procedure. In 1993, of the total produced wastewater estimated at 23.7 million m^3, about 1.82 million m^3 was treated and 1.56 million m^3 of this was reused. Total water withdrawal was estimated at 55.68 million m^3 in 1995, of which 87.3% was for domestic purposes (11.9% is withdrawn for agriculture and 0.8% for industrial use). Of the total quantity of groundwater used (22.72 million m^3), 17.2 million m^3 were used for domestic purposes, 5.41 million m^3 for agricultural and the remaining 0.11 million m^3 for industrial purposes. The desalinated water (31.4 million m^3) was all used for the provision of potable water in the public supply, which is equal to 65% of the total potable water supply. Of the total reused treated wastewater (1.56 million m^3); 1.22 million m^3 was reused in agriculture and 0.34 million m^3 in industry. In Malta, as in most Mediterranean countries, water is a scarce, over-exploited resource and desalination of seawater needs to be employed to meet demand for households and industry. Through its national legislation, accession to the European Union and other international commitments (such as the Barcelona Convention), Malta is committed to ensuring sustainability of Malta's water resources in a holistic manner (Malta Environment & Planning Authority). Water scarcity exacerbated by intensive human activity on a small land area is the main problem of Malta with limited natural water resources. As a consequence of groundwater depletion, a steady salinization of the groundwater sources has taken place over the last 20 years. For this reason, other alternative water supplies, like desalinated sea water and treated wastewater, will have to continue to be adopted so as to stop and reverse this depletion. The commitment of Malta to treat all sewage water produced by the year 2000 would make treated wastewater available to irrigate about 15 km^3, in addition to 5 km^3 irrigated by groundwater. However, the main constraints to achieving this potential are the funding of the irrigation network, realistic water charges and marketing prices. Domestic use of groundwater has top priority and hence further development of this source for irrigation is very limited. Through a more efficient use of water by means of micro-irrigation, there would be great potential for an expansion in irrigated areas. The government is financially assisting farmers to buy irrigation equipment by offering grants and subsidizing interest rates under the Financial Assistance Policy. (Water Action Hub, n.d.).

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Portugal

Portugal comprises three different areas: the mainland in the European Continent (the Mainland) and two archipelagos in the Atlantic Ocean, the Archipelago of the Azores and the Archipelago of Madeira. Portugal's territory has a total area of 92,226 km^2 and a coastline of 2,601 km. Portugal's population is estimated at 10.3 million (2020), of which 65.2% live in urban areas. In mainland Portugal, the resident population is concentrated along the Atlantic coast. Portugal is vulnerable to the climate change impacts from extreme events associated to lack (droughts) or excess (floods) of rainfall and heat waves. Sea level rise also is a threat to Portugal's coastline where significant amount of its population lives. (Climate Knowledge Portal World Bank, n.d.)

Map of Portugal (World Atlas, n.d.)

Climate

The climate in mainland Portugal is predominantly influenced by latitude, orography and its proximity to the Atlantic Ocean. Climate variables, such as precipitation and temperature, display strong north-south and west-east gradients as well as a very sharp seasonal and inter-annual variability. Average annual precipitation in mainland Portugal shows a strong spatial variability, with the highest values observed in the mountainous regions of Minho, exceeding 2,500 mm, and the lowest values, below 600 mm, in some northern and central inland regions (non-mountainous areas) and in inland Alentejo. On average, around 40% of annual precipitation occurs during winter (December to February) and only 7% of total annual precipitation occurs during summer (June to August). Transition seasons – spring (March to May) and autumn (September to November) – show a very variable inter-annual distribution, with approximately 24% and 28% of total average precipitation during these seasons, respectively. Average annual temperature is between 6°C and 9°C in inland North and Centre and higher, above 17°C in eastern Algarve and the Guadiana valley. (Climate Knowledge Portal World Bank, n.d.)

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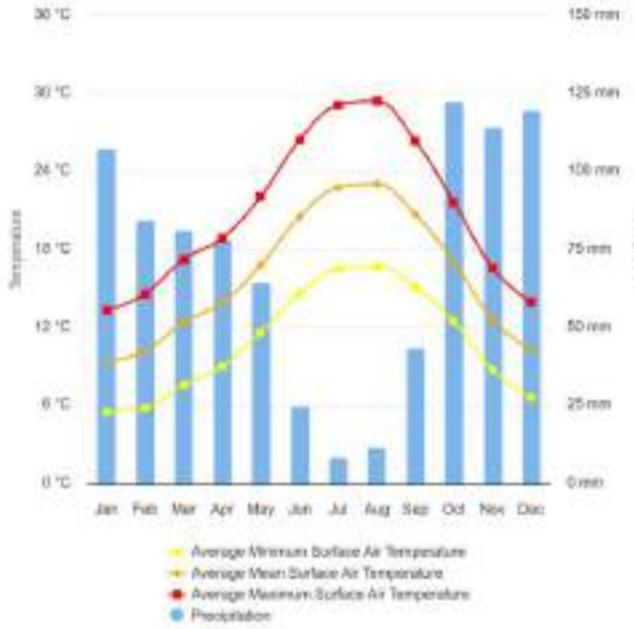

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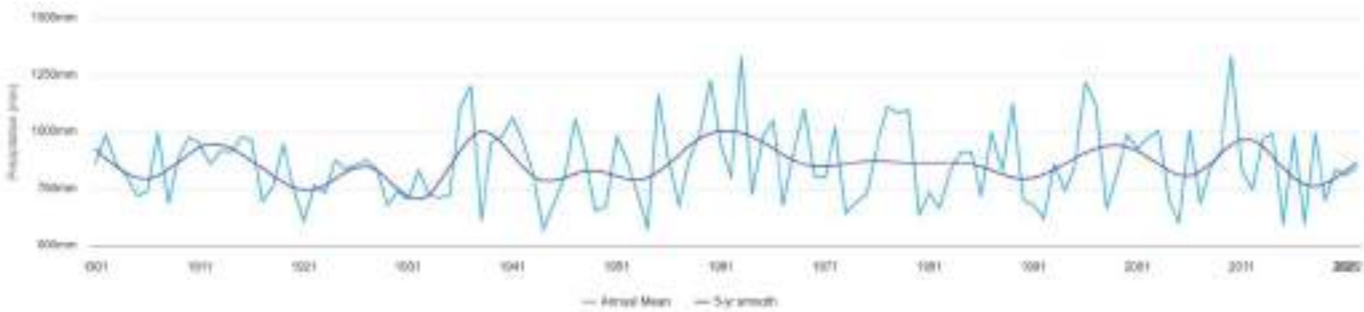
Observed Climatology of Percipitation 1991-2020; Portugal (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Percipitation of Portugal for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

Portugal has a mild climate, with rainy winters and warm summers. Extreme temperatures occur in the northeastern parts of the country in winter and the southeastern parts in summer. The Madeira and Azores Atlantic archipelagos have a milder temperature range. It has a long-term average annual precipitation of 854 mm/year. The long-term average of annual renewable water resources is estimated at 68,700 million m^3/year, of which 55% is considered internal water resources (38,000 million m^3) and 45% external water resources (30,700 million m^3). In 2009, the total dam (reservoir) capacity was estimated at 11,610 million m^3. Despite the high annual average rainfall and flow values, and although Portugal is a relatively small country, there is great spatial, seasonal and temporal variability in rainfall, which is exacerbated by climate change, making flooding and drought unpredictable and at times making it difficult to sustain water flows, both in national and international rivers. Portugal has 10 river basin districts (eight in mainland Portugal, one in the Azores archipelago and one in Madeira archipelago), of which four share water with Spain. The RBDs are: Minho/Lima; Cávado/Ave/Leça; Douro; Vouga/Mondego/Lis; Tejo; Sado e Mira; Guadiana; Algarve; Azores archipelago; Madeira archipelago. In terms of water resources, Portugal shares four hydrographic basins of five rivers (Minho, Lima, Douro, Tejo and Guadiana) with Spain. Three of Portugal's major rivers (the Tejo, Douro

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and Guadiana) originate in Spain, making Portugal dependent on Spain in terms of the quantity and quality of these resources. (Water Action Hub, n.d.)

Water quality

In 2008, coastal and transitional bathing waters achieved their best performance in five years, with 89.4% being categorised as 'good' and only 1.1% as 'poor', with the Regional Health Authority prohibiting bathing in 0.2% of waters. Inland bathing water recorded a decrease in compliance in relation to the mandatory values, the rate falling from 93.5% in 2007 to 92.8% in 2008. The same occurred with compliance in relation to the guide values, which fell from 43.5% in 2007 to 42.3% in 2008, a year in which bathing was prohibited in 5.2% of such waters. In terms of the quality of water bodies, the number of surface water monitoring stations recording quality as 'good' has increased year after year, reaching 35.5% in 2008. However, the number of stations recording 'poor' or 'very poor' has also increased, although only slightly (36.5%). These different statuses respond to those defined by the Water Framework Directive (Directive 2000/60 of the EU). One of the main factors responsible for water body degradation is nutrient enrichment, particularly in the form of nitrogen and phosphorus, as a result of the use of fertilizers in agriculture, urban wastewater discharges and the discharge of wastewater streams from agroindustry and other industrial sectors. It should be noted that nitrate and phosphorus enriched water was identified as a significant concern in all RBDs, as were inputs from Spain, which were identified in all shared river basin districts (RBDs). In addition, groundwater contamination, flooding, microbiological pollution and organic pollution (CBO5, ammoniacal nitrogen) were identified in seven out of the eight continental RBDs of Portugal. Nutrient enrichment leads to eutrophication issues in the water bodies, and is reflected in greater primary productivity and consequently in reduced dissolved oxygen and pH levels in the water. In extreme situations this can lead to loss of fauna and flora and a reduction in the quality of water for human consumption. In order to assess the trophic status of the principal reservoirs in continental Portugal for the period from 2004 to 2007, the total phosphorus and chlorophyll-a concentration was measured in 29 stations. Some 72%, corresponding to 21 reservoirs, were found to be eutrophic, and 28%, corresponding to eight reservoirs, to be mesotrophic. An analysis by river basin district shows that in the 2006-07 hydrological year the highest percentage of stations in which the status of reservoir water was categorised as eutrophic occurred in the Tejo (64%), Sado and Mira (57%) river basin districts. In the context of Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources, from 2004 to 2007 more than 90% of stations with a groundwater level above 5 m recorded a nitrate concentration of less than 40 mg/l. In addition, more than 80% of stations with a groundwater level of less than 5 m also recorded concentrations below the threshold of 40 mg/l. The results show that, for most monitoring stations, the average nitrate ion concentration in the water appeared to be stable. As regards nitrates in rivers, 100% of stations recorded concentrations below 25 mg/l for the maximum annual and winter average values. Annual and winter average concentrations in over 50% of stations were stable. Maximum concentrations tended to decrease in over 60% of stations. In reservoirs, more than 90% of stations recorded maximum annual and winter average concentrations below 25 mg/l. Annual and winter average concentrations in more than 70% of stations were highly stable. In summary, there were not considered to be any urgent situations in terms of groundwater nitrate concentration. A great deal remains to be done, however, despite the improvements brought about as a result of integrated planning under the national water plan, river basin plans, plans for the use of reservoirs and coastal development plans. (Water Action Hub, n.d.).

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Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy

Directive 91/676/EEC of 12 December, 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (known as the Nitrates Directive)

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Spain

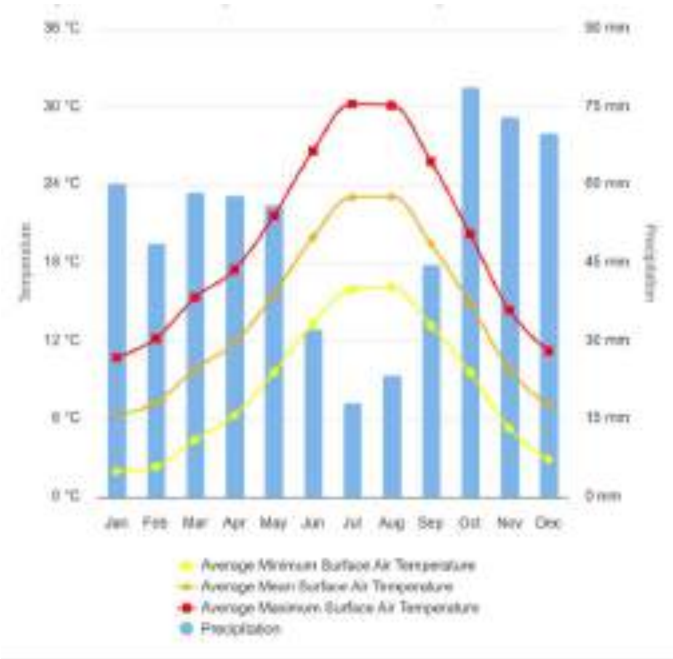
Spain is a country located on the Iberian Peninsula in Europe. Its territory of 506,023 km^2 makes it the second largest country of the European Union. Spain’s territory includes two archipelagos: the Canary Islands, off the coast of Africa and the Balearic Islands in the Mediterranean Sea. Other small islands in the Alboran Sea are also part of the Spanish territory. The country's mainland is bordered to the south and east by the Mediterranean Sea except for a small land boundary with Gibraltar, to the north and northeast by France, Andorra, and the Bay of Biscay, and to the west and northwest by Portugal and the Atlantic Ocean. Spain is particularly affected by droughts, with a huge variation in its precipitation rates. (Climate Knowledge Portal World Bank, n.d.)

Map of Spain (World Atlas, n.d.)

Climate

Given Spain’s orography and geographical location, the Iberian Peninsula experiences temperatures that exceed 45°C and minimums that reach values lower than -20°C. Average annual temperatures range between lower than 2.5°C, and higher than 18°C. (Climate Knowledge Portal World Bank, n.d.)

In the Iberian Peninsula, there are mainly three types of climates in agreement with the Köppen classification: (i) Dry climates (type B): BWh (warm desert) and BWk (cold desert), corresponding to the provinces of Almería, Murcia, and Alicante, where minimal rainfall occurs, and BSh (warm steppe) and BSk (cold steppe) for Extremadura and the Balearic Islands; (ii) Temperate climates (type C): Csa (temperate with dry and hot summer, known as Mediterranean climate) is found in approximately 40% of the surface of the Iberian Peninsula and the Balearic Islands, being the most common climate, it extends over almost all the southern half and much of the Mediterranean shoreline, Csb (temperate with hot and dry summer) in most of the northwest of the Peninsula and inland mountainous areas, Cfa (temperate without dry season with hot summer) in the northeast of the peninsula and in a strip of medium altitude in the Pyrenees, Cfb (temperate without dry season with mild summer) in the Cantabrian region; (iii) Cold climates (type D): Dsb (cold with dry and temperate summer) and Dsc (cold with dry and cool summer), Dfb (cold without dry season and mild summer) and Dfc (cold with dry summer and cool summer) in high mountain areas of the Pyrenees, the Cantabrian Mountains, and the Iberian System. (Abellán García et al., 2021)



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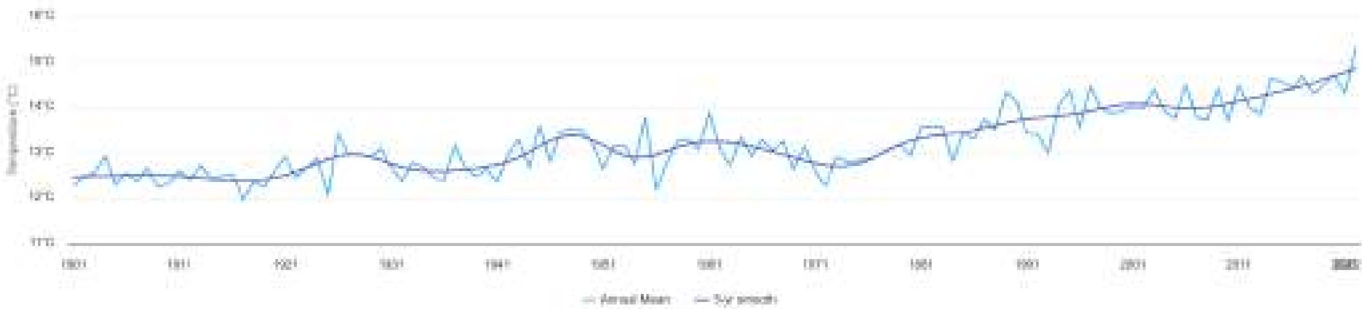
Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2020; Spain (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature of Spain for 1901-2022. (Climate Knowledge Portal World Bank, n.d.)

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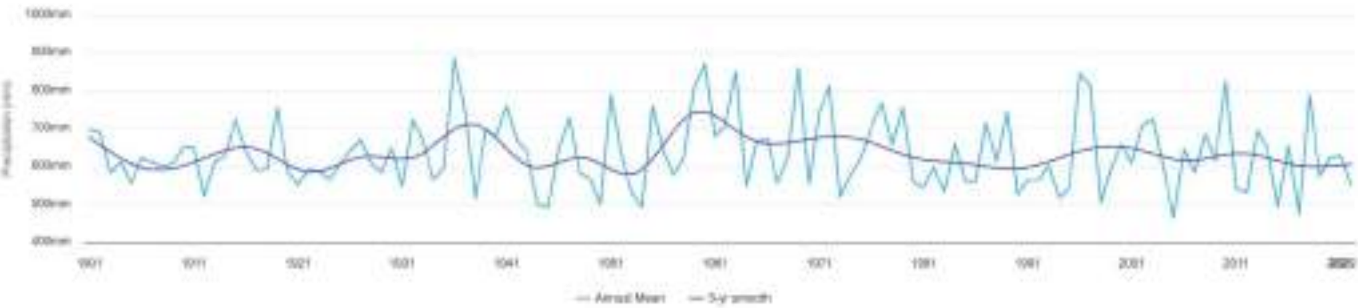
Observed Climatology of Percipitation 1991-2020; Spain (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Percipitation of Spain for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

This country shows several differences with regard to the water inputs and water demands distribution from the northwest to the south-east. Water inputs are composed by natural sources (surface and groundwater resources) together with non-conventional sources (interbasin transfers, desalination, and wastewater reuse). Surface and groundwater resources closely depend on (i) rainfall amounts which vary between 1000 mm/year and 1500 mm/year in the northwest, whereas values among 300 mm/year and 400 mm/year are recognized in the south-east; (ii) evaporation and evapotranspiration losses which reach their highest rates in the south-east of this country (an average real evapotranspiration of 335 mm/year is registered in the Segura River basin district. As a result, the south-east of Spain depicts low levels of natural available water. In Spain, the most relevant water demands are involved by agricultural, urban and industrial requirements. In south-eastern Spain, as a consequence of proper climate features and the growth of densely populated urban areas, agricultural, urban and industrial water demands have exceeded greatly the natural available water inputs. Therefore, during the last decades, numerous efforts, through interbasin transfers, desalination and wastewater reuse, were carried out in order to correct the identified negative balance. (Jodar-Abellan et al., 2019)

Water quality and wastewater treatment

Examples of successful use of wastewater in agriculture exist in Gran Canaria, where 20% of water used across all sectors is supplied from treated wastewater. Similarly, tertiary treatment of wastewater in the city of Vitoria, the administrative capital of the Basque Country, has provided 3 Hm^3/ year of irrigation water for nearby agricultural land, with a plan to increase the volume irrigated in the future to 8 Hm^3/year. Water supply in Spain throughout the 20th century has been based on building and enlarging water infrastructure rather than focusing on demand management. After dams and inter-basin water transfers, desalination has become the new alternative for solving the differences in supply between the ''dry'' and ''wet'' parts of the Iberian Peninsula. Spain is the largest user of desalination technologies in the western world. Globally, it ranks fourth behind Saudi Arabia, the United Arab Emirates and Kuwait, and first in the use of desalinated water for agriculture . In 1965, the first desalination plant in Spain was built in Lanzarote (Canary Islands). Desalination is also important on the other Balearic and Canary islands, and along the Mediterranean coast, especially near Málaga (where according to some estimates, desalted water may cover up to 40% of the water needs of the Costa del Sol) and in the provinces of Murcia and Alicante. Desalination is being presented increasingly as a techno-social fix, against the pressures of urbanization, climate change and population on freshwater resources. There is also a downside, however: negative effects on marine ecosystems, high-energy consumption and high CO_2 emissions. Furthermore desalination may increase water prices, induce uncontained urban growth, shift geopolitical relations of water security and increase dependence on technical expertise as well. Desalination, finally, and as happens with other large-scale water projects, such as water transfers, may fall prey to misleading projections of water demand based on scenarios of intense agricultural, urban and tourist growth. Over the last years, 95% of desalted water in Spain served urban and tourist purposes and only 5% went to irrigation. Desalted water is too expensive for farmers. Farmers turn to other options such as treated wastewater, water purchased from other irrigation communities, grey water reuse, rainwater harvesting, or even desalted water mixed with other water sources to decrease costs. (Climate Change Post, n.d.)

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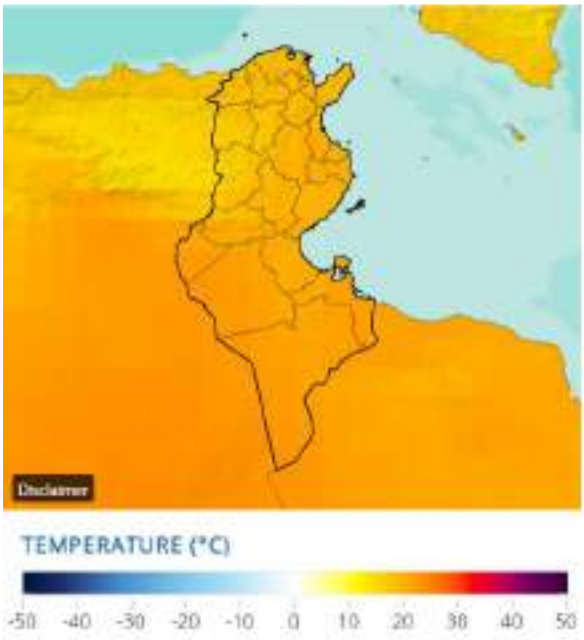
Tunisia

Tunisia is located within northern Africa along the southern shore of the Mediterranean Sea, between the eastern and western Mediterranean basins. It shares land borders with Algeria to the west and Libya to the southeast. The country has a total area of 164,000 km^2 and over 1,300 km of coastline along its eastern and northern borders. The country is divided in two large geographical areas, separated by successive low points occupied by the Chotts El Gharsa, Djerid and Fedjej, aligned from west to east. The northern area is diagonally crossed by the Tunisian Ridge, a mountain chain comprising the Tell Atlas and the Saharan Atlas Mountains. Northwest regions in the country are marked by high plains and a rugged landscape. The southeastern regions are dominated by a low and hilly landscape, which extends to the coast. The center-west regions, which extend south of the Tunisian Ridge are dominated by highlands bordering low and scattered mountain peaks and are occupied by steppes. Southern areas consist of the Saharan desert whose eastern border is represented by the Matmata and Dahar chains. (Climate Knowledge Portal World Bank, n.d.)

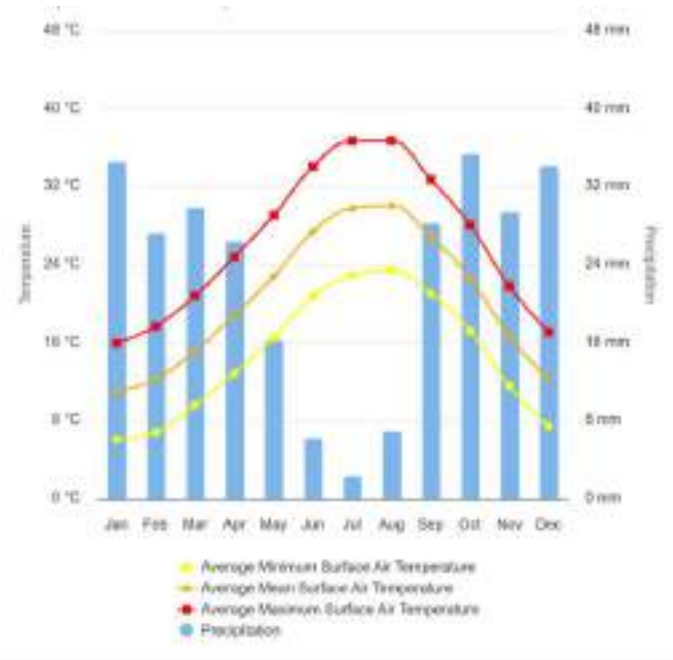
Map of Tunisia (World Atlas, n.d.)

Climate

Tunisia's climate varies due to the country's diverse geography, which can be divided into three regions. The northern mountainous region has a Mediterranean climate with mild, rainy winters and hot, dry summers. The south has a hot, dry, and semiarid climate as it enters the Sahara Desert, while the eastern coastal border has an arid steppe climate. Rainfall also varies by region, with average annual rainfall at 158 mm per year for the whole country, but less than 100 mm annually in the south and over 700 mm annually in the north. Historically, average temperatures likewise vary seasonally and regionally; in the northern coastal region temperature ranges from a low of 10°C in the winter months (December to February) to a high of 27°C in the summer months (June-August), while in the central western and southern regions temperature ranges from a winter low of 11°C to a summer high of 32°C. In the southern semiarid to arid areas, drought can be frequent, while the coastal region experiences floods. During the last 30 years, temperature increased by an average of 0.4°C per decade. Mean average temperature rose by 1.4°C in the twentieth century. While in aggregate no significant change in annual precipitation was observed from 1901 to 2013, over the past 30 years, average annual precipitation has decreased by about 3%. Autumn precipitation has increased in the northern and central regions of the country, while the west has experienced higher than average rainfall of up to 25 mm per month compared to less than 2 mm per month on average in other parts of the country. (Climate Knowledge Portal World Bank, n.d.)



Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Tunisia (Climate Knowledge Portal World Bank, n.d.)



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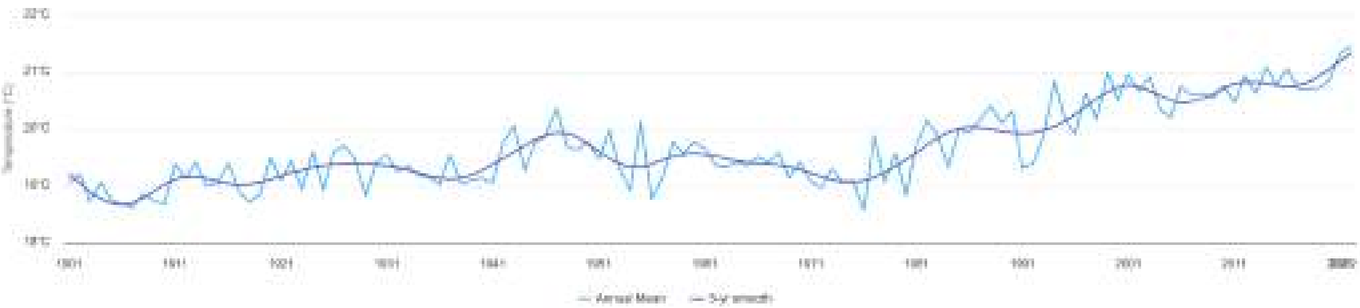

Observed Annual Average Mean Surface Air Temperature of Tunisia for 1901-2022. (Climate Knowledge Portal World Bank, n.d.)

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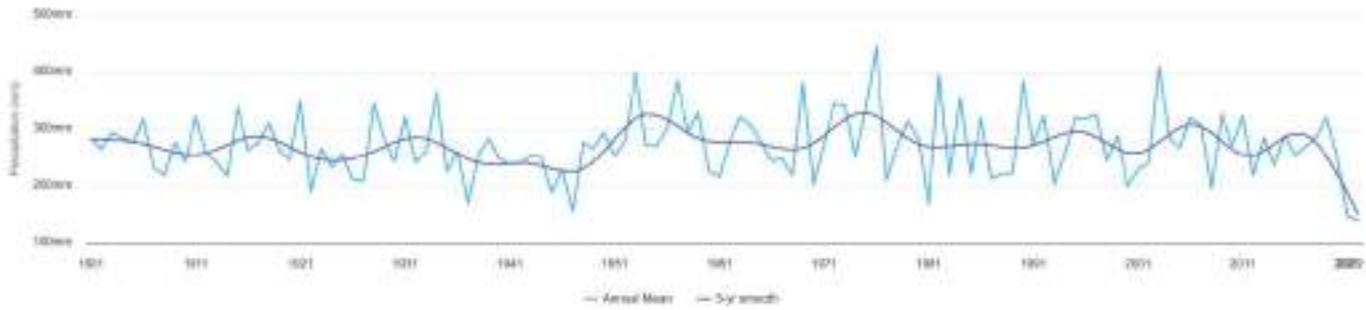
Observed Climatology of Percipitation 1991-2020; Tunisia (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Percipitation of Tunisia for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

Tunisia's river network is dense in the north where the Medjerda is the most important river. The northern basins provide regular and substantial contributions relative to the rest of the country, supplying 82% of surface water resources. Basins in the centre and south are characterized by low and irregular contributions. The north is also distinguished by its richness in shallow groundwater (in the northeast coastal plains). The centre is relatively well off in deep and shallow groundwater with an average to mediocre quality. The south is characterized by its low potential for renewable groundwater from continental infill (geothermal properties, temperature around 75°C). Natural wetlands, such as sebkhats, lagoons and saline lakes, with a total area of 8,220 km^2, are characteristics due to the topography, irregular rainfall and arid climate. Sebkhats are most common. These are inland depressions that fill with water in winter and dry in summer; salinity is generally high and variable. Lake Ichkeul (90 km^2) nature reserve is the most famous. Artificial lakes and dams are starting to grow; their present area is estimated at about 150 km^2. (Water Action Hub, n.d.)

Agriculture is the largest water user in the country, accounting for more than 75% of total water usage when agricultural use is not restricted. The low cost of irrigated water has led to its overexploitation. Although 90% of arable land is rainfed, irrigated agriculture consumes the largest share of water and contributes to 36% of the value added by agriculture. To improve surface water mobilization, between 35% and 56% of total agricultural sector investments since 1990 were related to water. However, the economic return of surface water mobilized for irrigated agricultural activity covers only 40% of the cost invested per cubic meter. Land-cover changes have had a significant impact on water yields, the storage capacity of dams, and other freshwater systems. Ecosystems, especially forests and oases, play a crucial role both as water reservoirs and in protecting dams from siltation by preventing or reducing both soil erosion and the transportation of debris that would otherwise be deposited in dams and weirs. Tunisia's surface water is mobilized from 37 large dams, which have a total capacity of about 2,313 Mm^3, primarily for local irrigation and livestock needs. Accumulated siltation in dams is reducing their ability to store surface water; indeed, in 2021, large dams had accumulated an average silting rate of 22.59%. The crucial role of ecosystems in supplying water has long been neglected, with freshwater allocated entirely to the needs of drinking water and irrigation. Intensive agriculture and the misuse of fertilizers have resulted in a decrease in groundwater quality, with the concentration of nitrates increasing. Tunisia's water scarcity is further compounded by suboptimal demand-side practices. The structural decline in water resource availability and increasing droughts have led to large-scale groundwater exploitation and illegal access to deep aquifers. When groundwater is extracted to excess, the pressure in the aquifer decreases, causing saltwater from the sea to enter and mix with the freshwater in the aquifer. Up to 85% of all groundwater resources already display salinity levels above the minimum threshold value of 1.5 grams per liter. (World Bank Group, 2023).

Water quality

For groundwater whose distribution covers the entire eastern coast of the country, they are threatened by overexploitation in many areas (Cap Bon, and Kairouan plain Gammouda Centre and Sfax to the south). As a consequence of this misuse, some groundwater salinization has become advanced (Cap Bon and Sfax) due to the intrusion of sea water. It seems that the quality of water resources (surface and groundwater) exceeds international health and/or agricultural standards since only 50% of these resources have a salinity of less than 1.5 g/l. From a quality perspective, approximately 72% of the potential surface water has a salinity of less than 1.5 g/l, whereas those drawn from aquifers, salinity is variable. For groundwater, only 8% can be considered weakly saline to freshwater. For the rest, salinity is sometimes greater than 5 g/l (92%). As for deep aquifers, salinity is relatively acceptable since 77% of them have a residue of less than 3 g/l. (Ahmed & Rouina, 2019)

Major environmental problems are health risks from ineffective disposal of toxic and hazardous waste; water pollution from raw sewage; limited natural fresh water resources; deforestation; overgrazing; soil erosion; desertification. Irrigation waters are relatively salty (1.5-4 g/l) but the degree of salinization of irrigated soils is not at unsafe levels because of leaching by irrigation water and rainfall. The latter, covering 23% of the area managed, are subject to regular monitoring of salinity, particularly for land that can be affected by the raising of groundwater levels. (Water Action Hub, n.d.)

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<u>**Türkiye**</u>

Türkiye is located between 36°to 42° N latitude and 26° to 45° E longitude in the Northern Hemisphere. The country shares borders with Bulgaria and Greece in the west, Georgia, Armenia, Azerbaijan/Nakhichevan and Iran in the east and Iraq and Syria in the south. The coastal border of the peninsula surrounded by three sides with the Black Sea in the north, the Aegean Sea in the west and Mediterranean in the south. Türkiye's total surface area is 785,347 km^2 with agricultural lands accounting for 31.1% of the country's land use. Türkiye's population is approximately 84.3 million (2020) people, of which 87.9% live in urban areas and 12.1% live in rural areas. As an upper-middle income country, Türkiye's economy is driven by its agriculture, industry, and services sectors, including tourism. Türkiye is vulnerable to the impacts of climate change from extreme weather events and increase in temperature. These have consequences on the country's terrestrial, marine and freshwater ecosystems and increases the overall strain on the environment. (Climate Knowledge Portal World Bank, n.d.)

Map of Türkiye (World Atlas, n.d.)

Climate

Türkiye is situated between the subtropical zone and temperate zone. The climate zones observed in Türkiye are the Mediterranean Climate where summers are hot and dry and the winters are mild and rainy; the Black Sea Climate where summers are cool and winters are warm in the coastal area and snowy and cold at the higher parts; the Terrestrial Climate where temperature differences between summer and winter and day and night are large, and the Marmara Climate showing the characteristics of a climate transition between the Terrestrial, Black Sea and Mediterranean climates. Türkiye receives most of its rainfall in winter and spring. In summer, the amount of precipitation decreases while the temperature and evaporation increases. Annual long-term mean precipitation is 574 mm. Meanwhile, the number of meteorological extreme events has increased particularly since 2000 (1981 – 2017). (Climate Knowledge Portal World Bank, n.d.)

According to meteorological observations in 2021, the annual average temperature was about 1 degree Celsius above the 1991-2020 average, while annual total precipitation was 9% below the 1991-2020 averages in Türkiye. With 1024 extreme weather events, 2021 was the year with the highest number of extreme events. There has been an increasing trend in extreme event occurrences, especially in the last two decades. Most of the extreme events recorded in 2021

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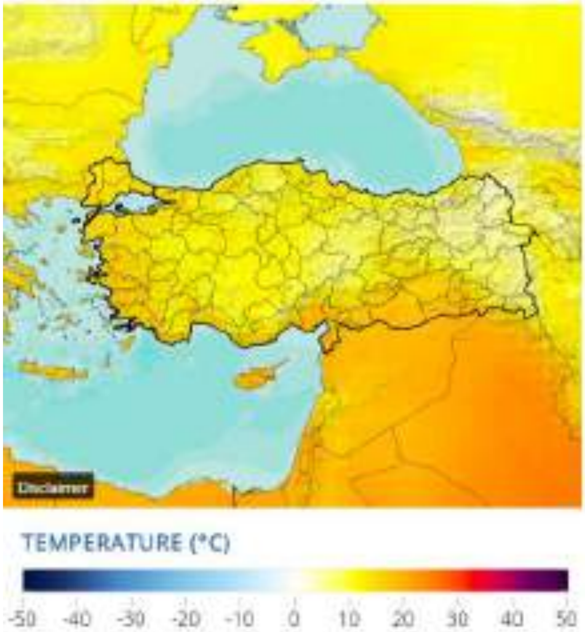
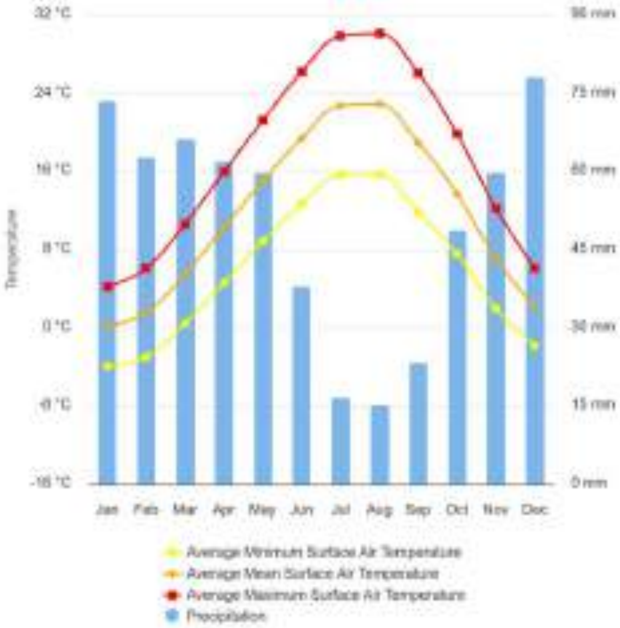
were storms/tornados (40%), heavy rain/flood (28%), hail (13%), and heavy snow (7%). According to climate change studies in Türkiye, annual precipitation averaged across Türkiye is expected to decrease by approximately 10% over the 2071-2100 period. On the other hand, in northern Türkiye, annual precipitation and heavy rainfall are likely to increase, with flood events becoming more frequent and intense. However, southern regions are likely to receive less precipitation, while droughts are becoming more frequent. (The Government of the Republic of Türkiye, 2023)



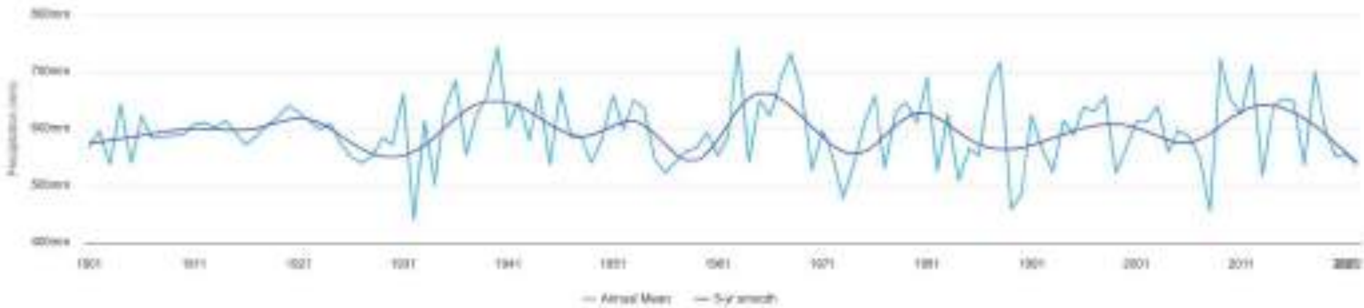
Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Türkiye (Climate Knowledge Portal World Bank, n.d.)



Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2020; Türkiye (Climate Knowledge Portal World Bank, n.d.)

Observed Annual Average Mean Surface Air Temperature of Türkiye for 1901-2022. (Climate Knowledge Portal World Bank, n.d.)

Observed Climatology of Percipitation 1991-2020; Türkiye (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Percipitation of Türkiye for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

Turkey is divided into 25 hydrological basins with large differences in specific discharge. Most of Turkey's rivers originate within the country. There are more than 120 natural lakes and 677 artificial lakes1. Total gross internal renewable water resources are estimated at 227 km^3/year. About 186 km^3 of this total is surface water, 69 km^3 is groundwater, while 28 km^3 is considered to be the overlap between surface water and groundwater. Of this 234 km^3, 112 km^3 is considered to be the annual net amount of economically and technically exploitable water. Average surface runoff entering the country from Bulgaria and Syria is 1.8 km^3/year – 0.6 km^3 from the Tunca River coming from Bulgaria and 1.2 km^3 from the Asi-Orontes coming from Syria. The Meriç River, originating in Bulgaria, forms the border between Greece and Turkey. It has a flow of 5.8 km^3/year, of which half (2.9 km^3/year) is allocated to Turkey. Adding the incoming flow to the internal renewable water resources brings the total natural renewable water resources to 231.7 km^3/year. Of the total flow of 53.74 km^3/year leaving the country, 28.1 km^3 flows to Syria (of which 26.29 km^3 is the natural outflow of the Euphrates), 21.33 km^3 to Iraq (Tigris and affluent), and 4.31 km^3 to Georgia. Groundwater flows to other countries are estimated at 11 km^3/year; this includes 1.2 km^3/year to the Khabour Springs, which feed the Khabour River in Syria and which have their origin in groundwater coming from Turkey. Taking into consideration the outflow and the flows reserved between countries, the total actual renewable water resources are 213.56 km^3/year. Turkey contributes about 89% of the total annual flow of the Euphrates, while the remaining part

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originates in Syria; nothing is added further downstream in Iraq. Turkey contributes 38% directly to the main Tigris River and another 11% to its tributaries joining the main river further downstream in Iraq. (Water Action Hub, n.d.)

Over two-thirds of the country's 25 river basins face severe water scarcity, including those hosting the largest cities and economic hubs such as Istanbul, Ankara, Izmir, and Antalya, as well as important agricultural areas, such as the Konya plains. By 2023, Türkiye's total water consumption will be 112 billion cubic meters, comprising 72 billion for irrigation, 18 billion for domestic use, and 22 billion for industry. Between 1990 and 2019, water demand for irrigation increased from 72% to 76.7% of total consumption. Increasing drought severity has exacerbated groundwater depletion, with water levels dropping by more than two meters in river basins such as Konya, threatening the long-term sustainability of agriculture and contributing to the occurrence of massive sinkholes. The 2020/21 drought left several reservoirs around major cities with their lowest water storage levels in 15 years: Istanbul's reservoir levels fell to less than 20% of capacity in early 2021, putting water supply services at high risk for the city's 16 million customers and other users, including industry. Climate change-related warming of the Marmara Sea, combined with widespread pollution from the discharge of untreated industrial and domestic wastewater, fertilizers and pesticides has also contributed to the mucilage crisis that threatens aquatic life, tourism, and fisheries. A World Bank assessment on water scarcity estimates that a 10% reduction of water supply from climate change would cost Türkiye 6% of GDP and about $50 billion. Although the study only considers climate change impacts on the agriculture sector, the economic impacts of growing water scarcity are significant and will deepen. Negative impacts are also likely in other key sectors, such as energy—as water is needed for cooling and hydropower production—and industry. Of course, variability and extreme events more broadly have negative impacts on the economy. In the event of a 100-year flood, more than 3% of GDP (or $20 billion) and 3 million people could be affected. (World Bank Group, 2022)

Water quality

The water quality of most rivers can be considered to be suitable for irrigating many soils and crops. In areas where agrochemicals are extensively used, the hazardous effects of pesticides and fertilizers threaten the use of groundwater sources for drinking water. Pesticide use in Turkey is the highest in the Mediterranean region, particularly in the Çukurova region south of Adana. But the Black Sea is also becoming polluted with agricultural pesticides, although the residues are not yet at a level to constitute a hazard for human health. Ergene Basin, Buyuk Menderes Basin, Sakarya Basin, Susurluk Basin, Marmara Basin, Gediz Basin are among the water basins in Turkey where pollution is a major threat. (Water Action Hub, n.d.)

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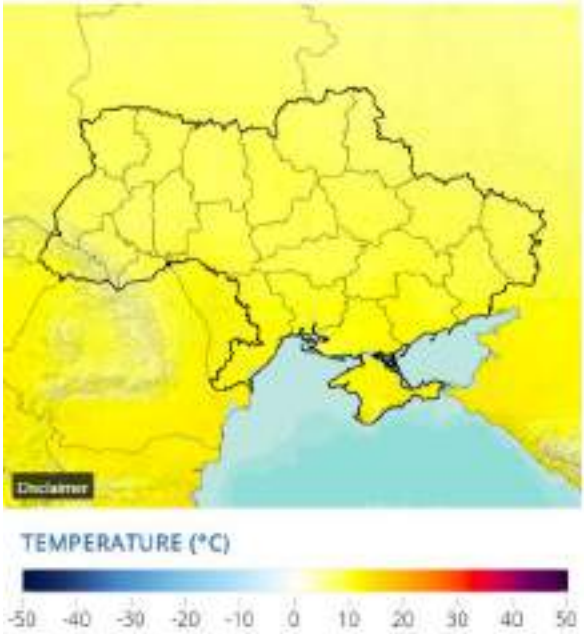
Ukraine

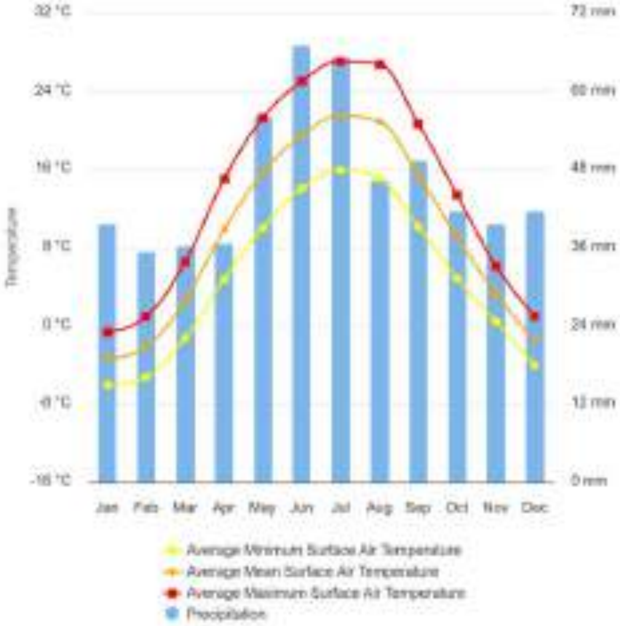
Ukraine is a country in Eastern Europe, sharing boarders with Russia, Belarus, Poland, Slovakia, Hungry, Romania, and Moldova. The country also has a coastline along the Sea of Azov and the Black Sea. Ukraine has a total land area of more than 600,000 km^2, with a largely flat topography except for the Crimean Mountains in the south and Carpathian Mountains in the West. The country is dominated by the Dnieper River which stretches north to south through the center of the country for over 2,200 km. Ukraine has an extensive network of rivers, more than 73 thousand, most of which are transboundary. Ukraine has a population of 44.1 million (2020) people, but has experienced negative population growth since 2000. The economy is dominated by industry (including mining, construction, electricity, water and gas) and agriculture sectors. (Climate Knowledge Portal World Bank, n.d.)

Map of Ukraine (World Atlas, n.d.)

Climate

Ukraine has a mostly temperate climate, with the exception of the Southern Coast of Crimea which has a subtropical Mediterranean climate. The country enjoys sufficient amount of sunshine and year-round rainfall, highly concentrated during the summer months (May to August). Rainfall is highly varied depending upon area of the country and seasonal variation patterns. Ukraine has an annual mean temperature of 7-9°C. Mean summer temperatures (May to August) range from less than 18°C to 22°C. Mean winter (December to March) temperatures range from -4.8°C to 2°C. Precipitation falls predominately in summer to fall months, with June and July typically having the highest rainfall (67 mm). (Climate Knowledge Portal World Bank, n.d.)





Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Ukraine (Climate Knowledge Portal World Bank, n.d.)

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2020; Ukraine (Climate Knowledge Portal World Bank, n.d.)

Observed Annual Average Mean Surface Air Temperature of Ukraine for 1901-2022. (Climate Knowledge Portal World Bank, n.d.)

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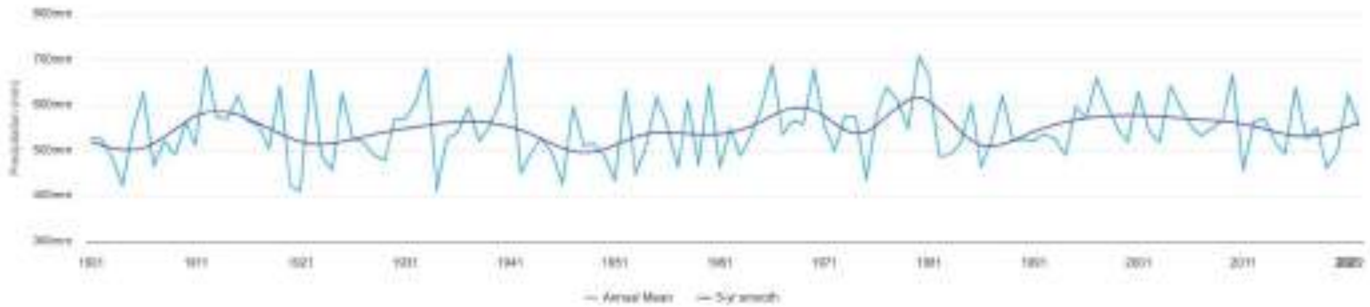
Observed Climatology of Percipitation 1991-2020; Ukraine (Climate Knowledge Portal World Bank, n.d.)



Observed Annual Percipitation of Ukraine for 1901-2022 (Climate Knowledge Portal World Bank, n.d.)

Hydrology and water quantity

The country can be divided into seven major river basins, all of them discharging into the Black Sea except the Northern Bug which flows towards the Baltic Sea: The Dnepr basin, covering about 65% of the country. The Dnepr River rises in the Russian Federation, then flows into Belarus before entering Ukraine. Its main affluents in Ukraine are: on the left bank, the Desna River, which rises in the Russian Federation; and on its right bank, the Pripyat River, which comes from Belarus and the Ingulets. The Dnestr basin, covering 12% of the country. It flows into Moldova before re-entering Ukraine some 50km before its mouth in the Black Sea. The Danube basin, covering 7% of the country. The final 120km of the Danube River before it reaches the Black Sea form the border between Ukraine and Romania. The Danube is the river with the largest number of riparian countries in the world. Some affluent of the Danube rise in Ukraine, in the Carpathian Mountains, flow into neighbouring countries, and join the mainstream of the Danube before its mouth at the Black Sea. In particular, the Cisa River flows out of Ukraine into Hungary, while the Prut River flows into Romania and Moldova. Ukraine contributes 7.5% to the total flow of the Danube. The coastal basin, covering 7% of the country. It includes all the small rivers which flow directly into the Sea of Azov and the Black Sea, including all the Crimean rivers. The Northern Donietsk basin, covering 4% of the country. It rises in the Russian Federation, and flows through Ukraine for about 450km in its eastern part before re-entering the Russian Federation. The Southern Bug basin, covering 3% of the country. It is an internal river basin, generating about 3.4km^3/year. The Northern Bug basin, covering 2% of the country. The Northern Bug River rises in Ukraine and flows north, forming the border with Poland, and then the border between Poland and Belarus. Like the Northern Bug, the San River rises in Ukraine before entering Poland where it joins the Northern Bug. The internal renewable surface water resources can be estimated at 50.1km³/year, while the total surface water resources can be estimated at 136.55km³/year. The groundwater resources are estimated at 20km³/year. Artesian wells are found at an average depth of 100-150m in the north of the country and 500-600m in the south. The overlap between surface and groundwater resources has been estimated at 17km³/year. In 1992, the total water withdrawal was estimated at 26km³, of which 30% was for agricultural purposes, and 52% for industry. A further 0.9km³/year was reported to be withdrawn for other purposes. A comparison with 1985 data shows that in the period 1985-1992 the total water withdrawn for agriculture declined by 2 km³, and for industry by 3km³. This might be explained by the decrease in irrigated area due to the lack of fuel and spare parts for the pumps, the decline in animal husbandry, and the drop in industrial production caused by the prevailing difficult postindependence economic situation. In 1989, wastewater treatment amounted to 3.8km³/year, which was 57% of the total produced wastewater at that time. Although nearly 100% of the population has access to safe water supply (in rural areas, mostly through wells), the existing network is overexploited. In the past, the agricultural sector was a priority for the government. In the 1960s, the Council for Dnepr River Resources Management was established with a mandate to prepare legal acts concerning the exploitation of the Dnepr, Northern Donietsk, Southern Bug, Crimea and Donbas regions. This programme was completed in the early 1980s. Public expenditure on water resources development for agriculture has fallen substantially since 1992. This fall has been caused by a lack of capital and by the undefined status of landownership over large areas. Combined with a lack of fuel to pump water to the irrigated land, this explains the recent decrease in irrigated areas. In the mid-1980s, the Soviet National Committee for Science and Technology launched a project concerning the automation of water resources management in the Dnepr basin. This project reflected the prevailing needs of industry, cities and irrigated agriculture in some districts. Indeed, one of the most crucial problems is, and will be in the future, the optimal use of river water resources. (Water Action Hub, n.d.)

Water quality

At the beginning of the 1990s, some rivers of the central and southern regions were exploited in their downstream courses to such an extent that aquatic life was endangered and basic environmental requirements were not satisfied. Salinity problems are concentrated mostly in the southern region. Major environmental problems are inadequate supplies of potable water; air and water pollution; deforestation; radiation contamination in the northeast from the 1986 accident at the Chernobyl nuclear power plant. (Water Action Hub, n.d.)

Water scarcity

Changing rainfall patterns and runoff indicate that future summer river flows are likely to decrease substantially, by as much as 50%, across central and eastern Europe, including the Ukraine. It is likely that the country will suffer increased water stress over the 21st century as severe droughts, classified today as one in 100 year events, are projected to become twice as likely by 2070. (Climate Change Post, n.d.)

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Estonia

Estonia is the northernmost and also the smallest country in the Baltic States, in terms of both population (1.3 million in 2020) and area (45,339 km^2). In 2016, 68.5% of the population lived in urban areas. Urban expansion is occurring in Estonia, which is resulting in the weakening of the position of most of the country towns and small towns. Almost half of the land of Estonia is covered by forests. The country has a very flat coastline and a number of islets, as well as large number of lakes and rivers. Estonia's country is dependent on high volume of the export of products and services, amounting to 90% of Estonia's GDP. The country is vulnerable to the impacts of climate change from sea level rise due to thermal expansion and the melting of glaciers, ice caps and ice sheets. Accelerated sea level rise could strongly affect the country due to its relatively long coastline and extensive low-lying coastal areas (World Bank, n.d.).

The geographical location of Estonia (Britannica, n.d.)

Climate

Estonia belongs to the mixed forest sub-region of the Atlantic continental region of the temperate zone and lies in the transition zone between maritime and continental climates. Summers are moderately warm (the mean temperature in July is 16 - 17°C) and winters are moderately cold (the mean temperature in February is between -2.5 and -7°C). The highest daily temperature ever recorded is 35.6°C and the lowest -43.5°C. Mean annual precipitation is 550-700 mm, ranging from 520 mm on some islands to almost 750 mm in the upland. Seasonal variation in precipitation is similar throughout the country, the driest months being February and March. Precipitation gradually increases until July and August, after which it decreases towards winter and spring (World Bank, n.d.).

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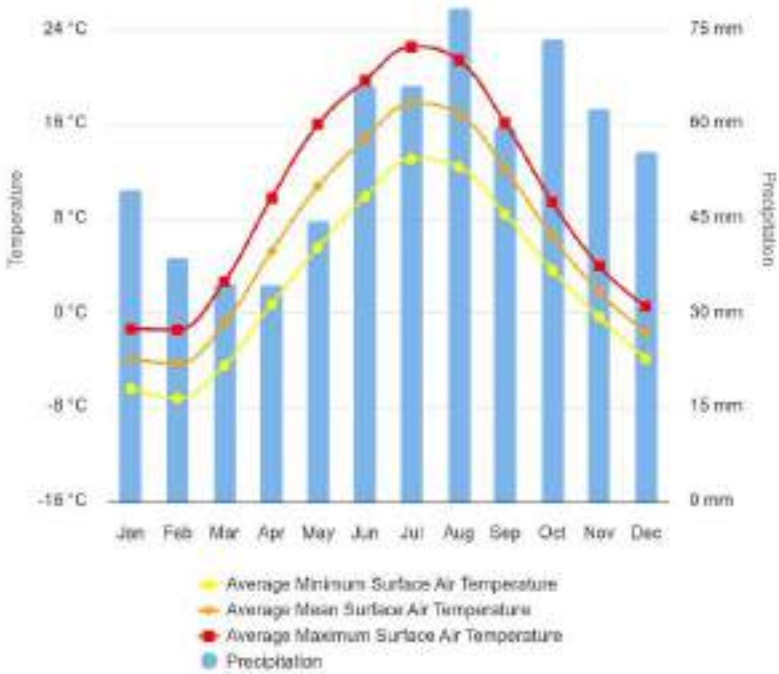
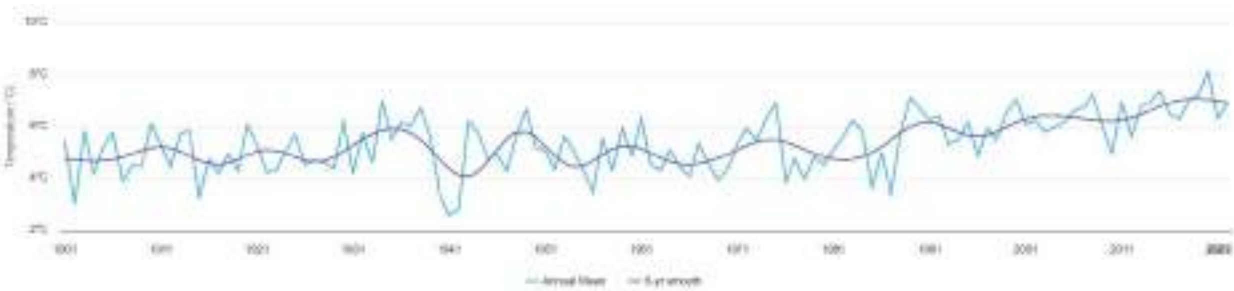


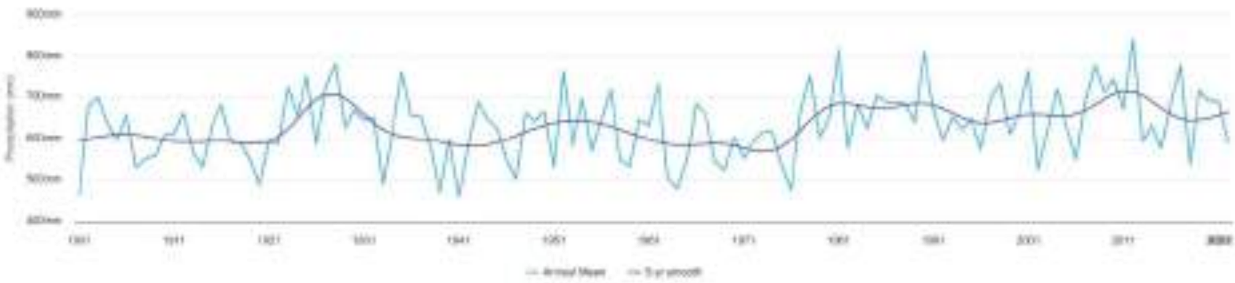
Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Estonia (World Bank, n.d.)

Observed Annual Average Mean Surface Air Temperature (left) and Precipitation (right) 1991-2020; Estonia (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature of Estonia for 1901-2022

(World Bank, n.d.)



Observed Annual Precipitation of Estonia for 1901-2022
(World Bank, n.d.)

Water quality

Eutrophication is a widespread and growing problem in many lowland waterbodies throughout the world and creates difficulties in water treatment. About 90% of the total supply to the city of Tallinn (population 400,000) is derived from Lake Ulemiste, which has a capacity of 17 million m^3. Lake Ulemiste is a highly eutrophic lake which is recharged by a major system of linked rivers, canals and reservoirs. At present, compliance with the drinking-water standard is consistently achieved, but this poses difficult treatment problems and high energy costs (especially in the pre-ozonation of the raw water and high levels of coagulant dosing), because of the variable seasonal quality of the raw water and high algal loadings in summer. Lake Ulemiste receives 90% of its recharge via a canal from the River Pirita - the latter being supplemented by an extensive regional canal system which traverses three major river systems to the east and south, covering a total catchment area of 1,865 km^2 (or 4% of Estonian territory). The proportion of the canal contribution into a balancing reservoir at Vaskjala can be varied by means of controlled releases from the Soodla and Kaunissaare reservoirs, and freshening supplies can supplement River Pirita flows by release from the Paunkula reservoir. The canal system (total length 67 km) is fed by a series of interlinked balancing reservoirs which are effectively ‘on-line’ to the natural river systems. Whilst supplies into the canal system can be controlled by the various sluices, the quality of the final water is a function of the natural characteristics of each subcatchment area (including point and diffuse sources of pollution from agricultural and urban areas). In recent decades, wastewater technology in small Estonian settlements has suffered from a lack of investment, and many small villages and towns in the watershed discharge partially treated sewage directly into the main river systems (Faulkner et al., 2002).

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Latvia

Latvia is situated on the edge of the Eastern European Plain near the Baltic Sea between 55°40' and 58°05' Northern latitude and between 20°58' and 28°14' Eastern longitude. The territory covers an area of 64,573 km^2 in total. Its length in the North – South direction is 210 km, and the width in the West - East direction - 450 km. Latvia is a typical lowland country and its terrain is characterized by flat, low areas and hilly elevations. There are more than 3,000 lakes and 12,000 rivers in Latvia. Total forest area (including afforested lands) in 2015 was 32,983.6 km^2, cropland 17,161.1 km^2 and grassland 7,380.7 km^2, wetland 4,451.8 km^2, settlements 2,541.4 km^2. Population of Latvia was 1.8 million as of 2020. As the economy of Latvia is small and open there is significant dependence on the trends of global economy. Foreign trade is important, with exports of goods and services accounting for about 45% of the GDP. The services sector had the dominating share in Latvia value added total followed by manufacturing and construction, while the agriculture sector and other industries had a minor role. Climate change in Latvia affects both its natural capital (species, habitats, ecosystems) as well as the health, welfare and safety and economic activities of the population (World Bank, n.d.).

The geographical location of Latvia (Britannica, n.d.)

Climate

Main drivers of climate conditions in Latvia are Latvia's location in northwest of the Eurasian continent, distance from Baltic Sea and the Gulf of Riga and relief of the territory of Latvia. Over the 1981-2010 normal period, the annual average air temperature is from +5.2 till +5.3°C in Alūksne and Vidzeme Uplands to +7.3 till 7.4°C in the coastal territories of the Baltic Sea, clearly illustrating the impact of continentality, proximity to the Baltic Sea and positive relief forms on the climatic conditions and the spread of their manifestations within the territory of Latvia. Air temperature has a seasonal nature – February being the coldest month with average air temperature -3.7°C and July being the warmest with +17.4°C. Annual precipitation amount in Latvia over the 1981-2010 normal period is from 590-670 mm in the Zemgale region to 770-870 mm in western parts of Vidzeme and Kurzeme Uplands. The least amount of precipitation is observed during the spring season, when the activity of the cyclones that were dominant during the autumn and winter seasons has ended, while the convective processes typical for the summer season have not yet begun. The highest amount of precipitation is observed in the summer season. On average, in Latvia there are

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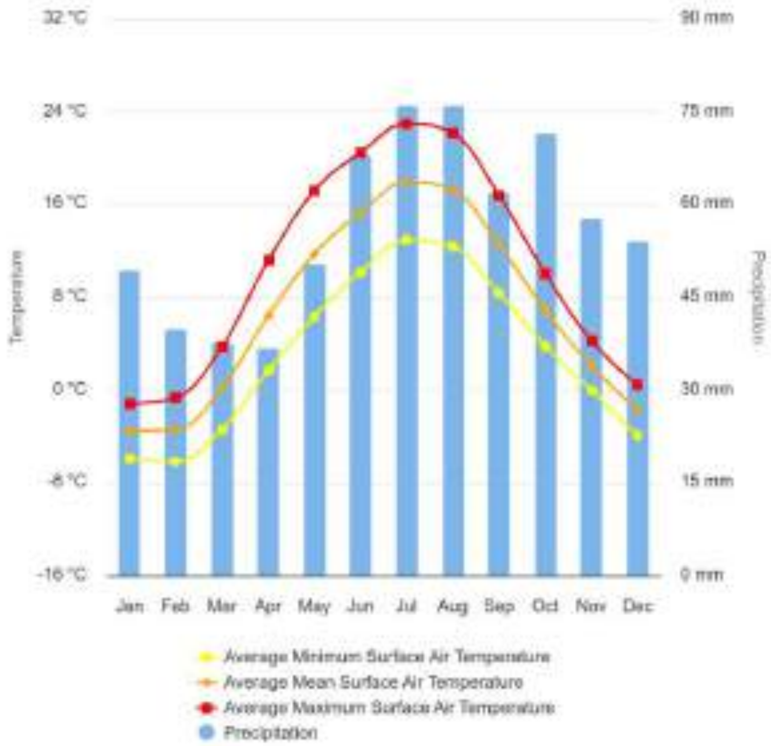
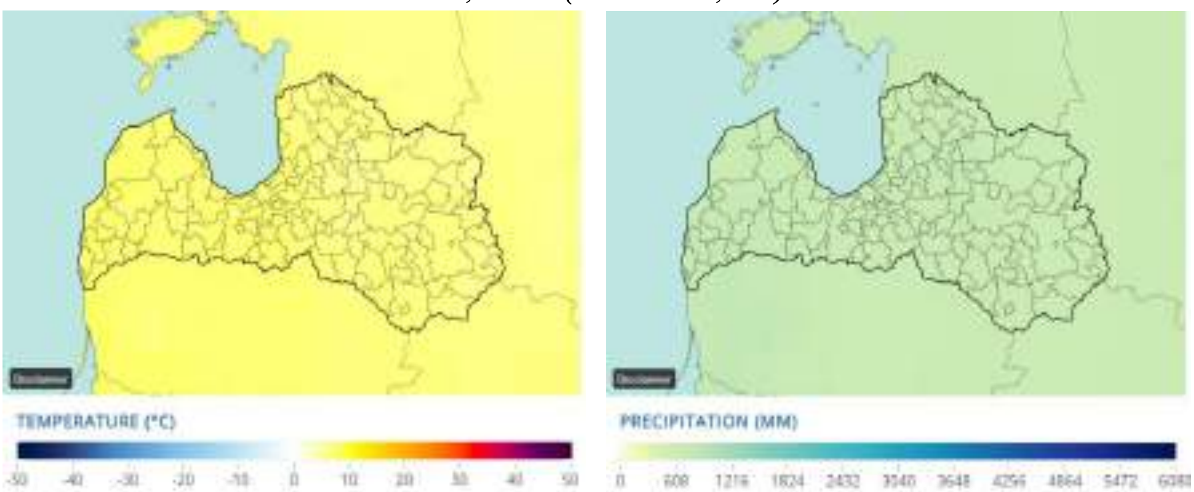
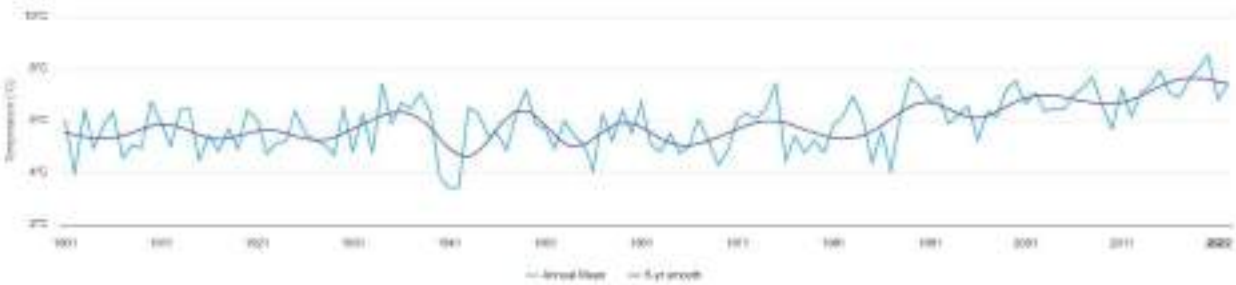
17 heavy precipitation and 4 very heavy precipitation days a year and the average annual maximum one-day precipitation amount is 34 mm. The highest recorded daily amount of precipitation is 160 mm (World Bank, n.d.).



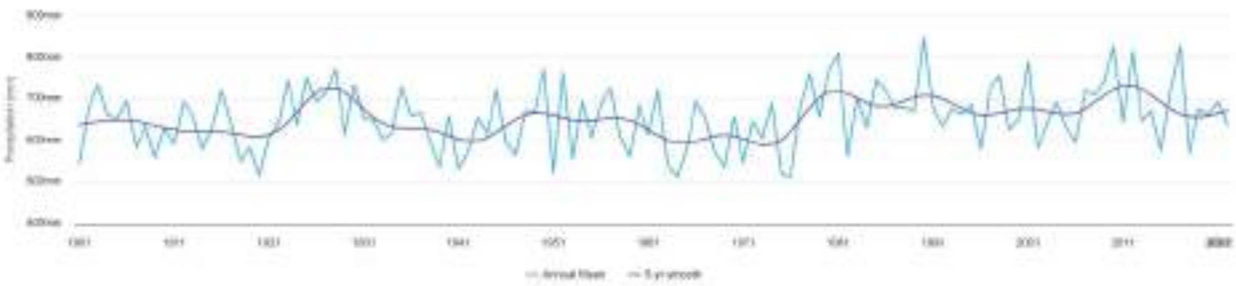
Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Latvia (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature (left) and Precipitation (right) 1991-2020; Latvia (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature of Latvia for 1901-2022 (World Bank, n.d.)



Observed Annual Precipitation of Latvia for 1901-2022
(World Bank, n.d.)

Hydrology

Depending on the physical and geographical conditions, a large part of the river discharge comes from snow melt, groundwater or direct surface runoff. About 50-55% of the waters of the Daugava, Venta, Lielupe and Musa rivers is melted snow, while for the Gauja and Amata rivers it is 35-40%. About 10-20% of the flow of some tributaries of the Lielupe (Memele and Svete) and the Aiviekste tributary of the Daugava is fed by groundwater, while for the Daugava and Gauja rivers it is 35-40%. In the Kurzeme peninsula and in the middle uplands, direct surface runoff accounts for 40% of the flow of the rivers, while in the Zemgales plain it represents 20-30%. The country can be divided into eight river basins:

The Daugava basin. Its total area is 87,900 km^2, of which 28% is located in Latvia. The Daugava River rises in the Russian Federation, flows through Belarus (where it is called the Western Dvina), enters Latvia in the southeast and flows northwest to the Gulf of Riga. Several tributaries enter the Daugava River inside Latvian territory, including four large ones: Ogre, Aiviekste, Dubna and Rezekne.

The Gauja basin. Its total area is 8,900 km^2, of which 88% is situated in Latvia. The Gauja River rises in the Vidzeme upland and flows east, then turns northwest, becomes the border between Latvia and Estonia for a short distance, and then flows southwest to the Gulf of Riga.

The Salaca basin. It covers the north of the country, near the border with Estonia. Its total area is 3,600 km^2, of which 92% is located in Latvia. The Salaca River rises in Lake Burtnieks in the north and flows west to the Gulf of Riga. -The Lielupe basin. Its total area is 17,600 km^2, of which 50% is situated in Latvia. The Lielupe River rises in Lithuania, enters Latvia in the south and flows north to the Gulf of Riga through the most fertile regions of the country. It has many tributaries, the most important being the Memela, Jecava and Svete.

The Venta basin. Its total area is 11,800 km^2, of which 67% is situated in Latvia. The Venta River rises in Lithuania, enters Latvia in the southwest and flows north through the Kurzeme lowland to the Baltic Sea. The Venta has many tributaries, but only one of them, the Abava River, exceeds 100 km in length.

The coastal basins between Lithuania and the Venta. Their total area is 5,100 km^2. This area includes rivers such as the Barta, Durba, Riva and Uzava, which flow to the Baltic Sea. -The basins within the coastal lowland, on the opposite shores of the Gulf of Riga. Their combined area is 3,800 km^2. This area includes rivers such as the Irbe, Stonde, Roja, Svetupe and Vitupe.

The Velika basin. This basin consists of a number of smaller rivers flowing into the Velika in the Russian Federation. Its area within Latvia is 3,200 km^2. The total discharge of the Velika amounts to 4.2 km^3/year, of which 16% is generated within Latvia. The total water resources are estimated at 16.54 km^3/year, incoming surface water resources at 18.709 km^3/year. The internal renewable groundwater resources are estimated at 2.2 km^3/year. Part of the groundwater flows to the sea or is withdrawn by wells, and part is drained by the surface network. That part of the groundwater flow which does not contribute to the total IRWR (overlap) is estimated at 2 km^3/year. Groundwater use

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is estimated at about 800,000 m^3/day. In some regions, rapid depletion of the water table is observed. Quite a large quantity is used by cities. In the Jürmala area, close to the capital Riga, the groundwater is famed for its medicinal qualities.

Water quality

The majority of the quality classes in Latvia for the surface water are in the top three classes and the water quality in Latvia is very good compared to some other countries around the world. Some of the major issues that the European Environment Agency tackles is water quality in nations within their jurisdiction and control. Latvia has one of the richest biodiversities in Europe and has done one of the best jobs of conserving, not only their water resources but also their other resources throughout the country. With the majority of the country covered by forests and other environmental footprints, the water quality is superior with it being untouched by humans. The water quality in Latvia can widely be considered in the high category with how much water is present. In some areas of the country, there is an excess of nutrients that have the ability to throw off the water content and the quality of the water, which can cause problems. The majority of the issues are very local and minor, which are dealt with accordingly. The are no serious threats to the water quality in Latvia. The water pollution is at a low level in Latvia with an estimate close to level 25. Meanwhile, the water quality is just over level 75, which is considered very good and of high quality. Since the 1990s, the average concentration of nitrogen and other nutrients has decreased in the water in Latvia. Pollution has seen a decrease as well over the last decade and it continues to lower as the years go on. The concentration of oxygen-consuming substances in the rivers in Latvia are low, which would indicate a good quality of the water in rivers. Latvia has moved in the right direction, having superb water throughout the country. Latvia will continue to be one of the richest states of nutrients and ecological conservation in the world and should continue to produce a high quality of water (Axtman, 2017). Latvia's environment has benefited from a shift to service industries after the country regained independence. The main environmental priorities are the improvement of drinking water quality and the sewage system; household, and hazardous waste management; and reduction of air pollution. In 2001, Latvia closed the EU accession negotiation chapter on the environment by committing to full enforcement of EU environmental directives by 2010. Eutrophication of water bodies and degradation of water ecosystems are priority environmental problems in Latvia, in relation to both inland and marine waters (CEO Water Mandate, 2020).

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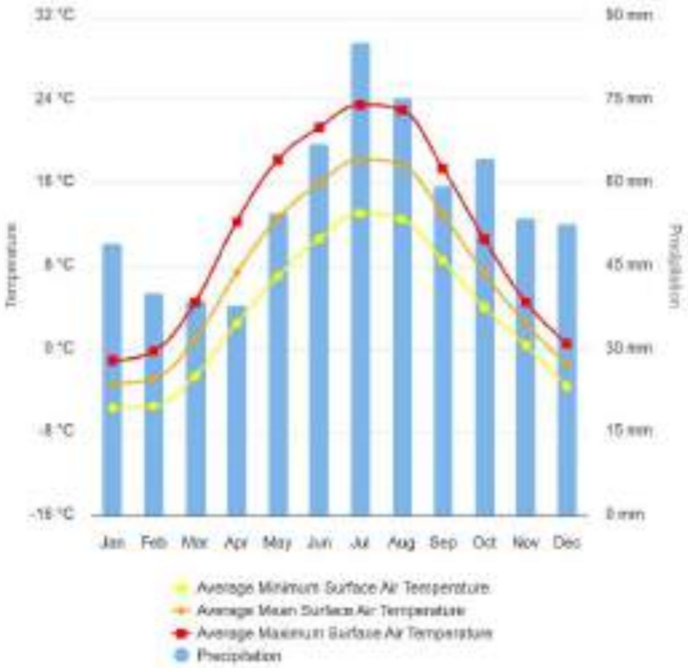
Lithuania

The territory of the Republic of Lithuania covers 65,302 km^2. Lithuania borders with Latvia, Belarus, Poland, Russia and the Baltic Sea. The coastal length of Lithuania makes 90.7 km. Lithuania is the country of lowlands with the highest hills not reaching 300 meters height. Agricultural land covers about 52.4% of the total land area of the country. The Lithuanian woodland occupies about 33.5% of the country's territory and protected areas - 17.6%. Its population was 2.7 million in 2020. Average density of population in Lithuania is 43.6 persons/km^2. The main economic activity in Lithuania is service sector, followed by industry and construction. Based on the results of previous studies in Lithuania, the Baltic Sea coast region is most vulnerable to climate change. Coast, coastal ecosystems, as well as local population are mostly affected by sea level rise, storm and hurricane winds, sea and Curonian Lagoon water warming and salinity changes (World Bank, n.d.).

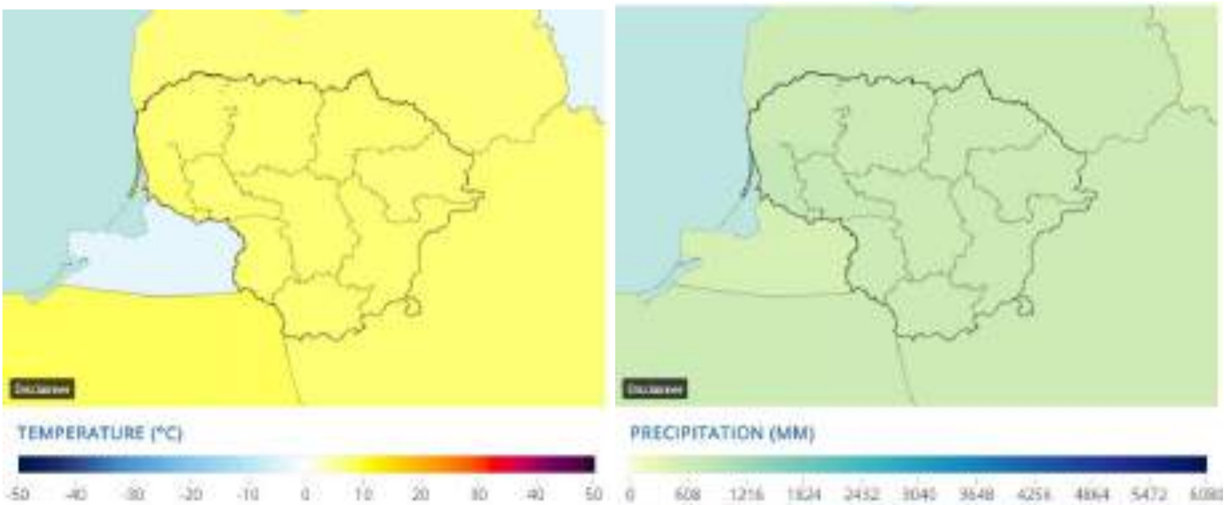
The geographical location of Lithuania (Britannica, n.d.)

Climate

The Lithuanian climate is formed and affected by the global factors and local geographical circumstances. Key features of the climate depend on the geographical location of the territory. Lithuania is located in the northern part of the temperate climate zone. The second global factor is the prevailing westerly airflow. Lithuanian territory, as the whole European region, lies in the area of influence of the Atlantic Ocean and westerly air flow, with air temperature, precipitation and runoff patterns, sea level and other parameters being largely determined by the North Atlantic Oscillation. The average annual temperature in Lithuania is 6.9°C. The 1981-2010 climatic normal precipitated rainfall is 694 mm. Most precipitation drops in west side (World Bank, n.d.).



Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Lithuania (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature (left) and Precipitation (right) 1991-2020; Lithuania (World Bank, n.d.)

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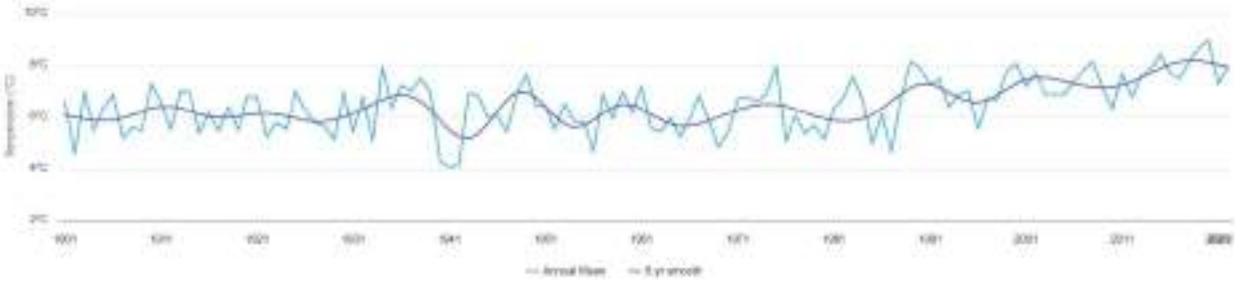
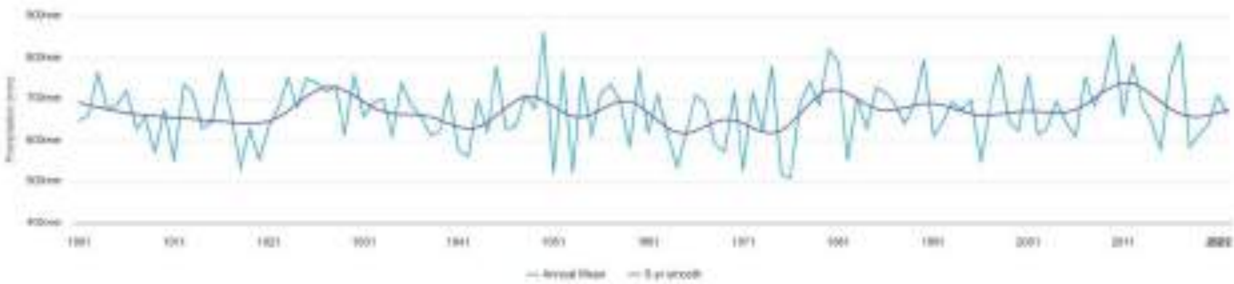


Observed Annual Average Mean Surface Air Temperature of Lithuania for 1901-2022
(World Bank, n.d.)



Observed Annual Precipitation of Lithuania for 1901-2022
(World Bank, n.d.)

Hydrology

Lithuania is located in the wet part of the world and is rich in freshwater resources. Rainfall during an average year amounts to 748 mm (from 570 mm to 902 mm). From a total average precipitation of 44.0 billion m^3/year, about 13.7 billion is river outflow (mainly to the Nemunas). The remaining 30.3 billion (or almost 69%) evaporate and infiltrate groundwater. The average density of the river network, including artificial water streams, is 1km/km^2. In recent decades, with the excavation of numerous landreclamation canals, the total density of the hydrographic network has almost doubled. There are over 29 900 rivers, rivulets and canals longer than 250 m; 758 rivers longer than 10 km; 18 rivers longer than 100 km and 9 rivers longer than 200 km. The length of the main water artery, the River Nemunas, is 937 km, of which 475 km flow through Lithuania. It rises in Belarus. The Nemunas is a tributary of Lithuania's largest inland water source, Curonian Lagoon. 413 km^2 of that Lagoon (out of 1 610 km^2) are in Lithuania. The rest lies in the Kaliningrad region of the Russian Federation. It is separated from the Baltic Sea by the overgrown and picturesque Curonian Spit. The total length of the second largest river - the Neris - is 510 km, of which 276 km flow through Belarus. The river Òventoji runs entirely through Lithuania and is 249 km long. The total annual river flow in Lithuania (including transit flow) is 26.1 billion m^3. Over 75% of rivers and rivulets have been regulated by land reclamation. Of the 63 700 km of natural rivers only 17 000 have remained unregulated, including the 9 largest rivers (UNEP, 1999).

Water quality

Pollution from urbanized areas along rivers is especially severe. The discharges from the seven biggest cities, or 44% of the population, make up about 67% of all discharges. In terms of BOD7, this is 74%, nitrogen discharges are 64% of the national total and phosphorus discharges 60%. Pollution caused by industry has decreased over recent years, partly as a result of reduced economic activity in certain key sectors. Surface water quality is monitored in 47 rivers and 9 lakes, at the points which most characteristically reflect the impact of municipal, industrial and agricultural activities. The set of parameters, about 70, is quite extensive. Natural background concentrations are observed in the 6 smaller rivers least affected by economic activity. 43% of rivers are classified as being clean, 48% as moderately polluted and 9% as heavily polluted. In the heavily polluted rivers – Sidabra, Kulp, Obel, Tatula, Laukup – concentrations of organic matters exceed standard limits 10-fold, those of nitrates 13-fold and ammonium and phosphates up to 26-fold. The water quality of the main river Nemunas varies along the course of the river. In the uppermost reaches it is excellent or good, downstream from the main cities it is polluted. There have been no significant changes in recent years in the water quality of the Nemunas. It is estimated that one third of organic and total nitrogen loads of the river are discharged from sources in the Kaliningrad region. The poorest water quality is observed in the Òiauliai region. The main problem in Lithuania's rivers is heavy loading of organic matter. In many cases phosphorus and nitrogen concentrations as well as hygiene parameters indicate serious pollution. The only significant trend in the water quality of Lithuania's lakes is the increase in nitrate concentration in almost all the lakes and increasing BOD in two lakes. Lithuania's lakes have a high buffer capacity and thus acidification is not a problem. Assessing the likely future development of the lakes is difficult, since no information is available on the activities affecting them (UNEP, 1999). The rivers of Lithuania will become particularly vulnerable in summer. If the climate change scenarios come true, spring and autumn floods will change greatly. In summer, the water quality will suffer from low flows. The maximum summer temperature of lakeswill rise and therefore the processes of eutrophication will accelerate (Climate Change Post, n.d.).

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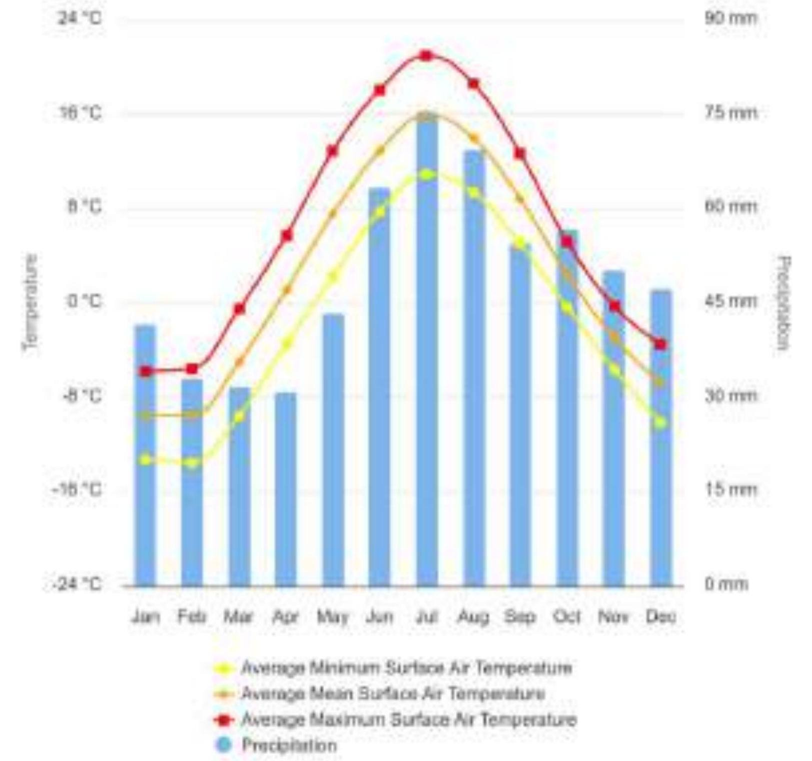
Finland

Finland is situated at a latitude between 60° and 70° N, with a quarter of the country extending north of the Arctic Circle. In the west and south, Finland has a long coastline with numerous islands along the Baltic Sea coast. With a total area of 338,400 km^2, it is Europe's seventh largest country. The land boundary with Sweden is 614 km long, with Norway 736 km long and with Russia 1,340 km long. Finland lies between the Scandinavian mountains and northern Russian plains. Its terrain is a varying mosaic of low hills, broad valleys and flat, low-lying plains, with higher fells in the north. The landscape is a mixture of forests, lakes and mires. Much of the country is a gently undulating plateau of mostly ancient bedrock. Nearly all of Finland is situated in the boreal coniferous forest zone, and 72% of the total land area is classified as forest land, while only some 9% of it is farmed. Finland has more than 34,300 km^2 of inland water systems, which is about 10% of its total area. There are some 190,000 lakes and 180,000 islands, with almost half of the latter existing along the Baltic Sea coast. The main manufacturing industries include electrical and electronics, forest and metal and engineering industries. Foreign trade is important, with exports accounting for approximately 40% of the gross domestic product (GDP). The cold climate, energy intensive industry structure and long distances have led to a relatively high energy intensity and per capita greenhouse gas emissions. Finland was one of the first countries in the world to adopt a National Adaptation Strategy to Climate Change in 2005. The current national adaptation policy framework is described in the National Climate Change Adaptation Plan 2022 adopted in 2014. Its aim is that the Finnish society has the capacity to manage the risks associated with climate change and adapt to changes in the climate (World Bank, n.d.).

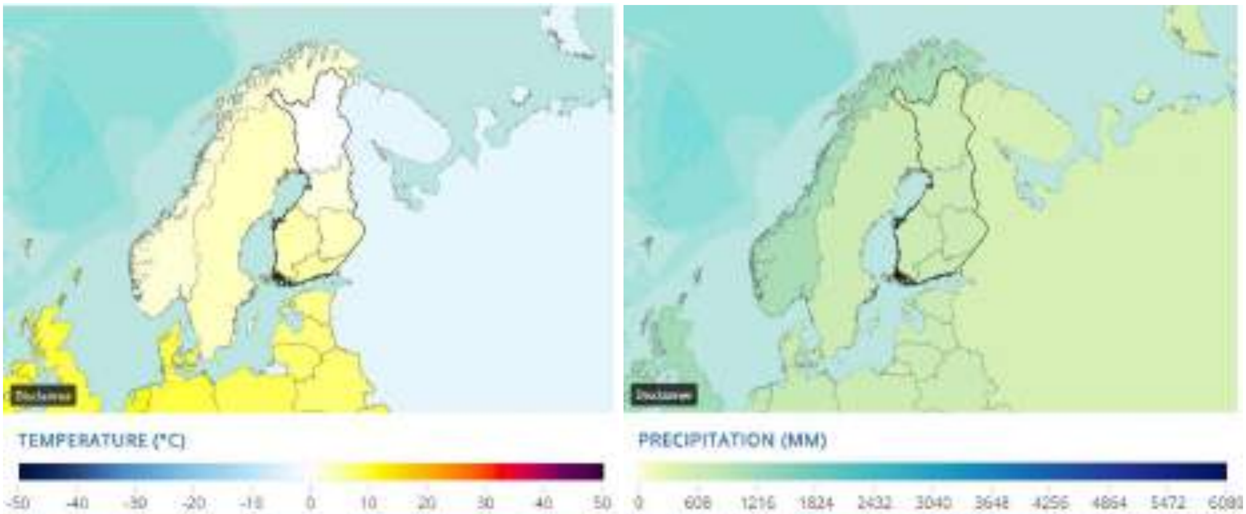
The geographical location of Finland (Britannica, n.d.)

Climate

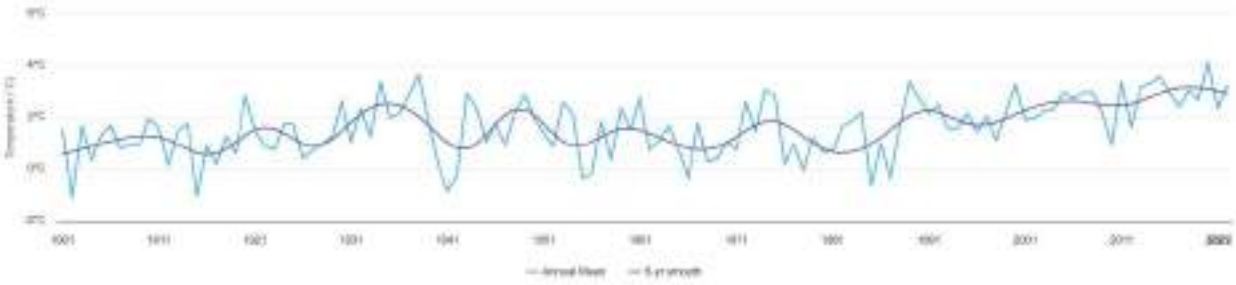
The climate of Finland displays features of both maritime and continental climates, depending on the direction of air flow. Considering its northern location, the mean temperature in Finland is several degrees higher than in most other areas at these latitudes, e.g. Siberia and southern Greenland. The temperature is higher because of the Baltic Sea, due to the inland waters and, above all, as a result of the air flows from the Atlantic Ocean, which are warmed by the Gulf Stream. The mean annual temperature is approximately 5.5°C in south-western Finland and decreases towards the northeast. The 0°C mean limit is approximately as far north as the Arctic Circle. Temperature differences between regions are the greatest in January, when the difference between southern and northern Finland is, on average, approximately 10°C. In June and July it is closer to 5°C. The Finnish climate is characterised by irregular precipitation and typically there are rapid changes in the weather. The mean annual precipitation in southern and central Finland is usually between 600 and 750 mm, except near the coast, where it is slightly lower. In northern Finland, the annual precipitation is 450 to 650 mm. The seasonal variation in precipitation is similar throughout the country, with the driest months being February, March and April. From then on, precipitation gradually increases until July and August, or until September and October on the coast, after which it decreases towards the winter and springtime. The lowest annual precipitation ever recorded was less than 300 mm in northern Finland, while the country's maximum recorded precipitation exceeded 1,100 mm. The highest daily precipitation ever recorded was almost 200 mm, but values above 50 mm are not very common. During an average year, more than half of the days have some precipitation, except near the coastal regions. During severe winters, the Baltic Sea may freeze over almost completely, but during mild winters it remains open for the most part, except for the Gulf of Bothnia and the eastern part of the Gulf of Finland (World Bank, n.d.).



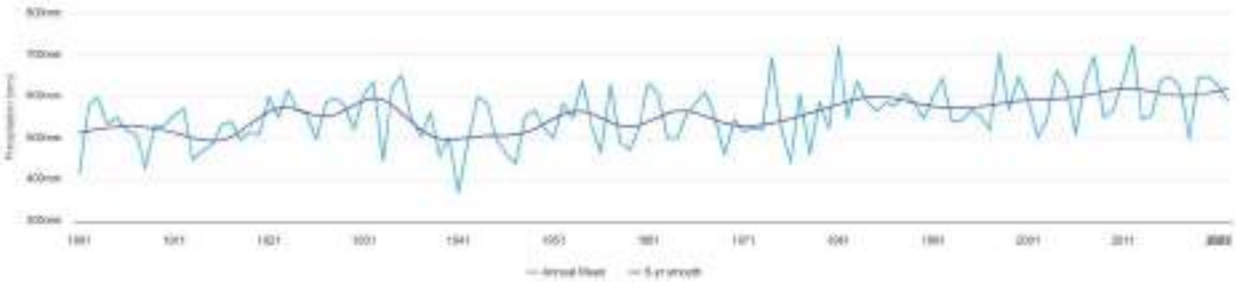
Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Finland (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature (left) and Precipitation (right) 1991-2020; Finland (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature of Finland for 1901-2022 (World Bank, n.d.)



Observed Annual Precipitation of Finland for 1901-2022 (World Bank, n.d.)

Hydrology

Finland is uniquely rich in surface waters, with a grand total of 187,888 lakes and ponds larger than 500 m^2, and rivers totalling 25,000 km in length. Almost a tenth of the country's total land area is covered by water. The total length of the intricate coastlines of the Baltic Sea in the west and the south add up to an impressive 46,000 km when the shorelines of islands are included. Although Finland has plenty of aquifers, these resources are not distributed evenly across the country. The most significant aquifers are in large moraine and esker features made of sands and gravels deposited at the end of the last Ice Age approximately 10,000 years ago. Water is typically clean, well oxygenated, and often also easily extractable. The Salpausselkä deposits in southern Finland in particular hold important aquifers (CEO Water Mandate, 2020).

Water quality

Compared with many other countries, water resources in Finland are rich. Renewable freshwater reserves amount to an estimated 21,000 m^3 per inhabitant, whereas the threshold for water poverty has been set at 1,700 m^3 per person. In Finland significant loads of pollutants enter water bodies in runoff from farmland, managed forests or peat mining sites; in wastewater from municipal wastewater treatment plants, industrial facilities, or livestock facilities; in effluent from fish farms; in wastewater from houses in rural areas with no public sewerage system; and in storm water from built-up areas, mines and quarries, or landfills. Significant quantities of pollutants from previously contaminated sediments and soils can also gradually leach into water bodies. Pollutants deposited from the atmosphere, such as acidifying substances, can also impair the state of water bodies. Significant point source activities are obliged to monitor their discharges in accordance with the Environmental Protection Act. For diffuse sources of pollutants, models or calculation methods are used to estimate total discharges. Pollutant loads from industry, municipal wastewater treatment plants and fish farms have been effectively reduced in Finland. However, diffuse loads from farmland, managed forests and scattered rural settlements have proven to be much more difficult to curb.

Eutrophication and excessive plant growth, especially in lakes with shallow water levels, have been the main problems in many Finnish lakes in spite of the effective reduction by the 1990s of point source nutrient loading. Eutrophication is still a major problem particularly in small lakes due to loading from diffuse sources, internal phosphorus loading and changes in the food web. The most popular in-lake restoration methods of eutrophic lakes have been aeration (including deliberate destratification) and food-web management. Control of macrophytes, raising of the water level and dredging have been applied in overgrown shallow lakes and shore areas. About 50 new projects have been launched annually. The aquifers in Finland's glacial deposits rank in quality among the best reserves of groundwater in the world. Groundwater in Finland is generally soft, with low concentrations of dissolved substances and low pH (6-7). Most of Finland's groundwater is of good quality, since it is better protected against contamination than surface water. In some coastal areas where groundwater is scarcer, however, water has had to be extracted from beneath clay deposits, and such reserves may have high iron and manganese content. In coastal areas, excessive groundwater extraction may also cause salt water intrusion to contaminate wells. Harmful concentrations of arsenic, fluorine and radon occur in certain areas due to local geological features (CEO Water Mandate, 2020).

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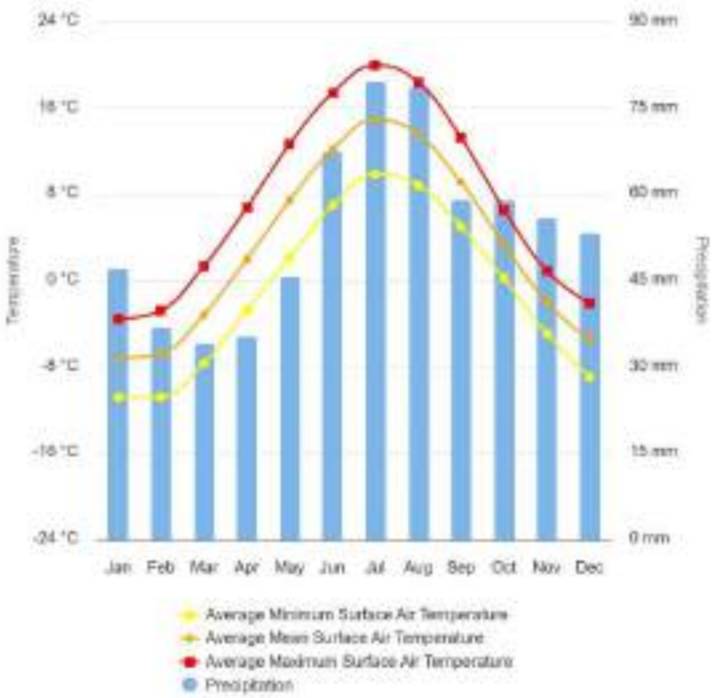
Sweden

Sweden extends from latitudes 55° N - 69° N and longitudes 11° E - 23°E, with a land area of 408,150 km^2. Urban land makes up 3% of the land area, while productive forest land account for 58%, farmland 8%, wetlands 13%, mires, rock surface, subalpine woodlands and high mountains 17%, and other land 2%. Inland water systems total more than 40,000 km^2, or more than 9% of the total area. In the past 50 years, farmland has successively given way to other land uses, mainly forest land. This has resulted in reduced emissions from agriculture and increased carbon sequestration in forest biomass. Sweden's population is approximately 10.4 million (2020). Sweden's economy is supported by its services, manufacturing, construction, and industry sectors that have resulted in a strongly export-oriented economy in Sweden (World Bank, n.d.).

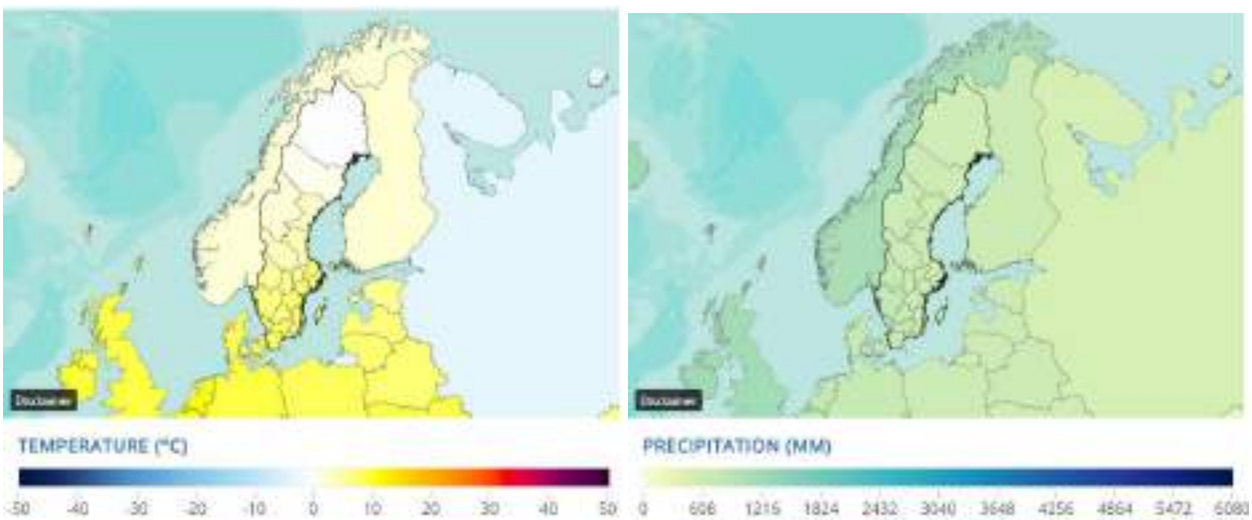
The geographical location of Sweden (Britannica, n.d.)

Climate

Sweden's proximity to the North Atlantic and prevailing south-westerly to westerly winds result in a climate that is mild in the winter months, but the northernmost part of the country has a sub-Arctic climate with long, cold and snowy winters. In the period 1961-90 the mean temperature in January was 0°C in southernmost Sweden, while the coldest northern valleys had 17°C. The maximum daily mean July temperature was approximately +17°C in south-eastern Sweden and just over 10°C in the north. Passing low-pressure systems bring precipitation that is fairly copious all year round, but heaviest in the summer and autumn. Annual precipitation is some 1,000 mm. Since most low-pressure systems move in across the country from the west or south-west, the western parts of Sweden receive the most precipitation (World Bank, n.d.).



Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Sweden (World Bank, n.d.).



Observed Annual Average Mean Surface Air Temperature (left) and Precipitation (right) 1991-2020; Sweden (World Bank, n.d.).

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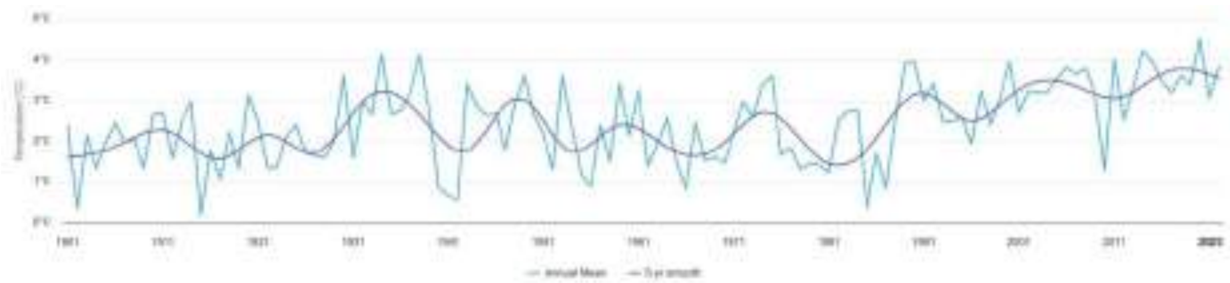
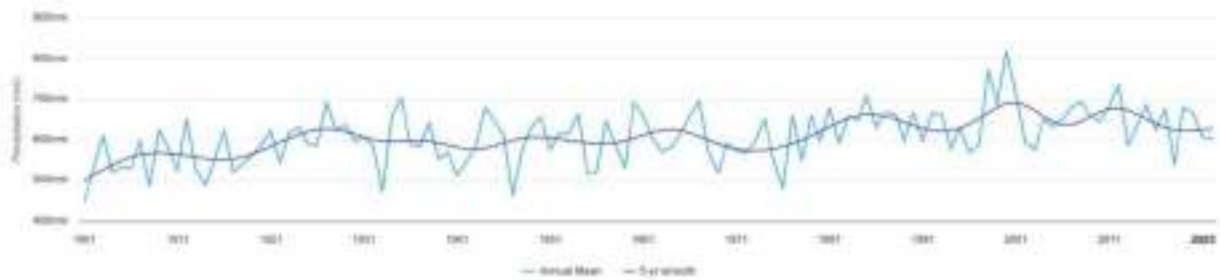


Observed Annual Average Mean Surface Air Temperature of Sweden for 1901-2022 (World Bank, n.d.).



Observed Annual Precipitation of Sweden for 1901-2022 (World Bank, n.d.).

Water quality

Farms use large quantities of fertilizers. Arable soil is also often enriched with animal manure. The risk of phosphorus and nitrogen leaching out of fields into adjacent watercourses, lakes and coastal areas depends on factors including what crop is grown, the soil type, precipitation, irrigation and harvesting On average, a third of nitrogen fertilizer applied to arable land brings no benefit, since it is not absorbed by the crops. More than half of this surplus leaches out into surrounding waters. Wetlands where ditches have been dug, lakes that have been lowered and watercourses that have been straightened out contribute to the ongoing massive leaching of nutrients from farming areas, since the previous obstacles to this leaching no longer exist. In lakes and watercourses it is almost always phosphorus, a plant nutrient that causes eutrophication, that leaches. Small lakes, in particular, are affected. The lakes that are hypereutrophic (where eutrophication is most severe) are in south Skåne, Mälardalen, Östergötland and south of Lake Vänern. The process of lakes becoming overgrown is partly a natural one that has been underway since the Ice Age, when the lakes were formed. But eutrophication has accelerated this process. Eutrophication largely follows the same patterns in watercourses as in lakes: the worst-affected watercourses are those in the agricultural plains of southern and central Sweden. Some of the nitrogen that leaches from arable land enters groundwater. As a result, concentrations of nitrogen in the form of nitrates have risen in many wells in the farming areas of southern and central Sweden. Elevated concentrations of nitrates represent a marked health risk for people who get drinking water from their own wells. Infants, who are vulnerable to nitrates, are particularly exposed to the risk that this well water poses. Nitrates reduce absorption of oxygen into the blood and can also be converted into carcinogenic substances in the body (CEO Water Mandate, 2020). Half of Sweden's local water supplies come from surface water, that is, from lakes and running watercourses. The other half come from groundwater. Good quality raw water from these water sources has made purification techniques in Sweden relatively simple. The consequences of climate change for drinking water supply, however, are considerable (Climate Change Post, n.d.).

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<u>**Netherlands**</u>

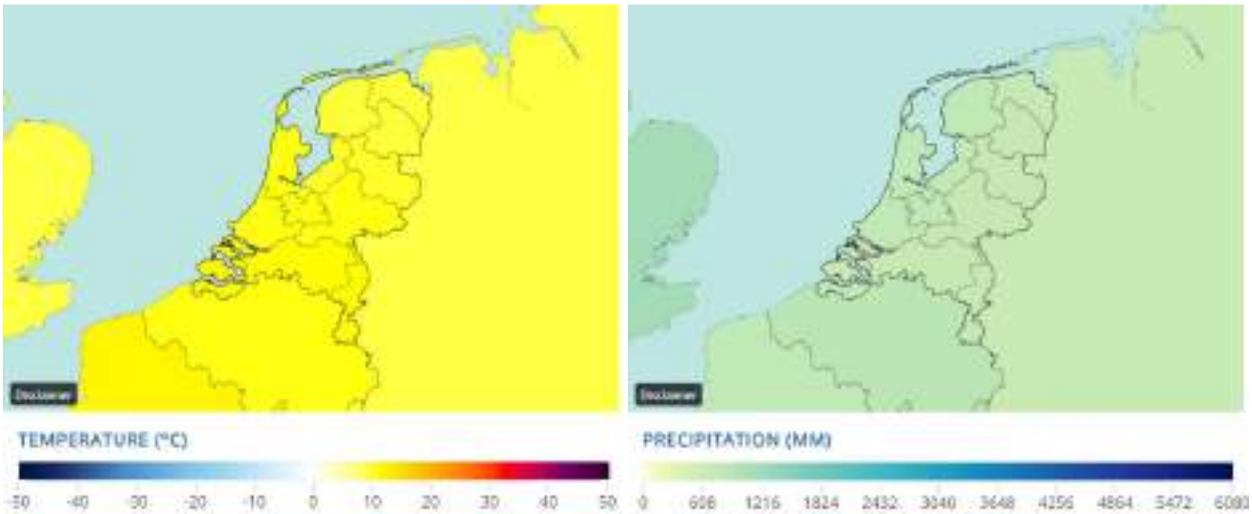
The **Netherlands** is a low-lying country situated in the delta of rivers Rhine, IJssel and Meuse, with around 24% of the land below sea level. The highest point is 321 meters above sea level, at the border with Belgium and Germany, and the lowest point is 7 meters below sea level. The surface area of the land, plus inland and coastal waters, amounts to 41,543 km^2. The land surface covers 33,680 km^2, of which 54% is used as agricultural land. While the use of land for agricultural is decreasing, land use for settlements and infrastructure is increasing, on the other hand. Forests make up roughly 10% of the land use. The Netherlands is a densely populated country. The population amounts to over 17.4 million people (2020), with approximately 507 persons per km^2 in 2017. The Netherlands ranks relatively high on the list of agricultural exporters. The climate in the Netherlands is expected to undergo significant changes over the coming decades. The most pressing consequences are increasing heat stress, increasing flood risks due to both more extreme river discharge and sea level rise, more frequent failure of vital infrastructure like electricity and IT, more frequent damage to crops or production resources, increased health burden and productivity loss, and changes in biodiversity (World Bank, n.d.).

The geographical location of Netherlands (Britannica, n.d.)

Climate

The Netherlands is located in the ‘temperate zone’. Throughout the country, mean winter temperatures are about 3°C and mean summer temperatures are around 17°C. Coastal regions have more hours of sunshine than inland regions and a relatively small annual and diurnal temperature range. The 30-year annual average temperature in the centre of the country is 10°C, while the mean annual average at 52°N is close to 4°C (World Bank, n.d.).

Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Netherlands (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature (left) and Precipitation (right) 1991-2020; Netherlands (World Bank, n.d.)

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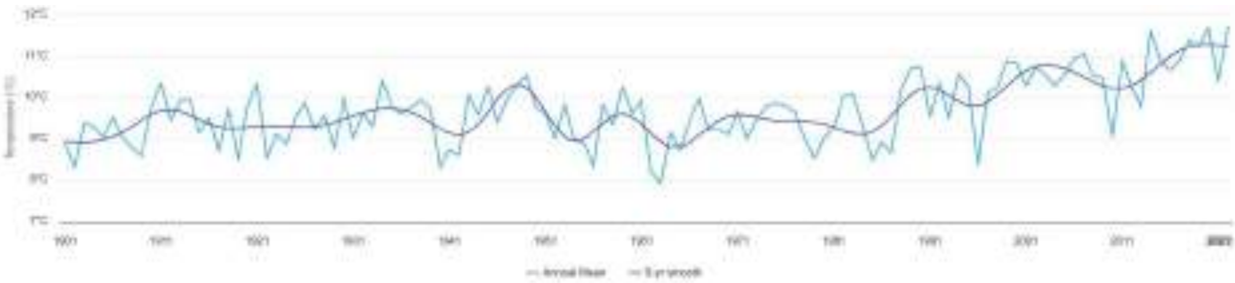
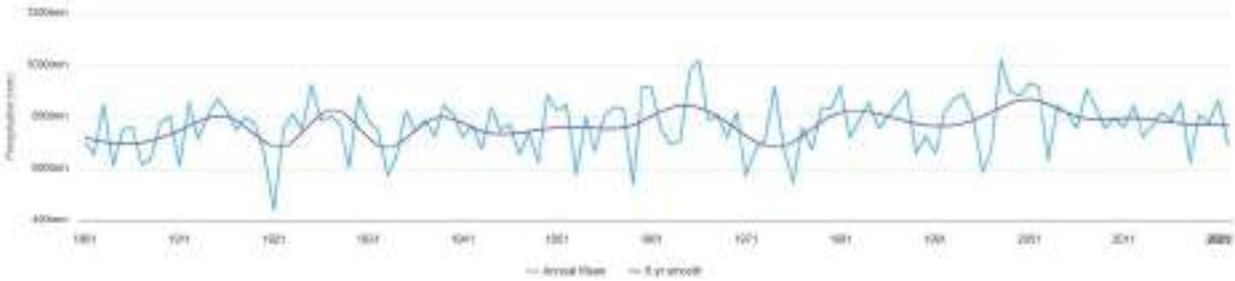


Observed Annual Average Mean Surface Air Temperature of Netherlands for 1901-2022
(World Bank, n.d.)



Observed Annual Precipitation of Netherlands for 1901-2022
(World Bank, n.d.)

Water quality

The quality of the water in Dutch rivers and lakes, sea water and ground water fluctuates. The composition of the water is generally good. However, water plants, fish and other animals in surface water in the Netherlands have not always the composition that represent the ideal environment. In the [Water Framework Directive](European Commission, n.d.) standards have been set for different substances for each type of water body (drainage ditches, lakes, rivers, coastal water, ground water.) Surface water quality is assessed in two ways. Firstly, it is assessed whether water is chemically healthy. That is to say, whether certain dangerous substances are found in the water (such as lead, cadmium and mercury) and, if so, in what concentrations. If the water is chemically healthy, it is said to be in 'a good condition chemically'. A body of water is given this appraisal if it remains within the standard limits set by the European Union (EU) for all substances. The standards are recorded in the Decree on Quality Standards and Monitoring for Water 2009 (in Dutch). Then the ecological quality of the body of surface water is assessed. To what extent are there fish, algae, water plants and small animals present? The temperature of the water and the presence of nutrients and a number of chemical substances fall under this assessment. If the score remains within limits that have been harmonized within the European Union (EU), then the water body is said to be in an 'ecologically good condition'. The numerical values that are linked to the EU targets are recorded in the Water Framework Directive Monitoring Programme (in Dutch). There are quality standards that pertain to ground water as well. These standards are recorded in the Decree on Quality Standards and Monitoring for Water (2009, in Dutch). Of the four river basin regions named, the Rhine delta and the Scheldt score the best results. More than 80% of the surface water in these river basins has been given a ‘good’ score. The Ems (60%) and Meuse (25%) score significantly less well. Substances that regularly exceed the set maximum limits are: crop protection agents, PAHs, PCBs, copper, zinc and ammonium, cadmium and tributyltin. The primary sources of these pollutants are agriculture and industry. Human and veterinary medicines form a separate problem. The remnants of medicines are secreted and thus increasingly are found in Dutch surface water. Drinking water is collected from this surface water (especially in the western part of the country). However, the amounts of medicine found are low and have a negligible effect on public health. The quality of the water plants in the salt water and brackish water areas is poorer than it is in fresh water. The concentrations of nitrogen are above the norm limits in all three areas. This is caused by the drainage of nitrogen (manure) from the land. An overabundance of nitrogen in the water can occasionally lead to an excessive growth of algae. The murkiness of the water also regularly exceeds the norm. Murky water is often a result of the dredging of the waterway (Netherlands Government, 2022).

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Denmark

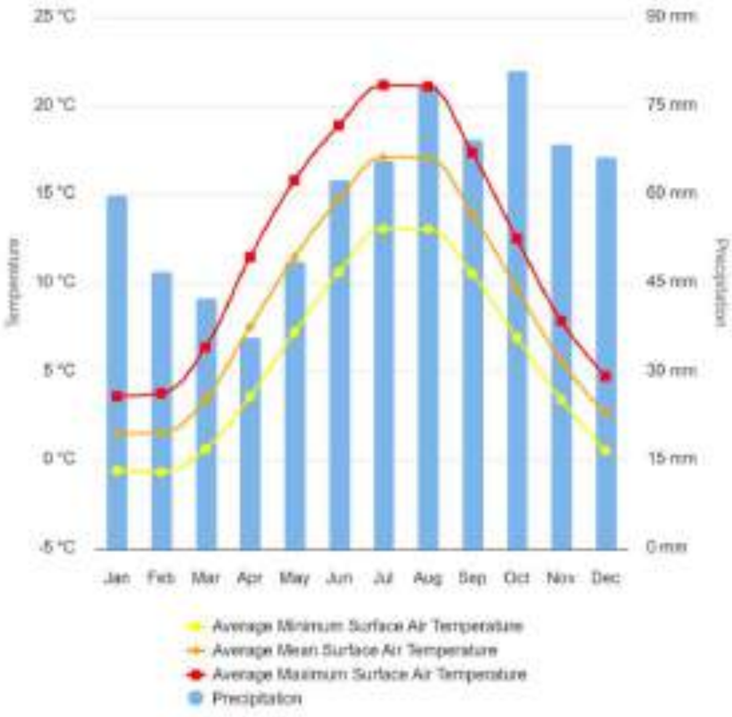
Denmark lies at about 55º N and 11º E and consists of the Jutland peninsula and more than 400 islands. Denmark has a population of 5.7 million as of 2020 and a total area of 43,000 km^2. More than 61% of the area is used for agricultural purposes, while 13% is forested and 14% is towns, roads and scattered housing, while the rest consists of natural areas, including lakes, watercourses, heath, among others. Denmark has a distinctly coastal climate, with mild, damp winters and cool, unsettled summers. However, the weather in Denmark is greatly affected by the proximity of both the sea and the continent. This means that the weather can change, depending on the prevailing wind direction. Denmark's coastline has a length of more than 7,300 km. To protect low-lying land against flooding and storm surge, it has been necessary to build dikes or other permanent installations along about 1,800 km of coastline. A rise in the water level due to climate change would obviously affect the protection of the coasts and create a greater risk of flooding and erosion (Seventh National Communication, 2017). Denmark submitted its Nationally Determined Contribution (NDC) as an EU Member State in 2015 (World Bank, n.d.).

The geographical location of Denmark (Britannica, n.d.)

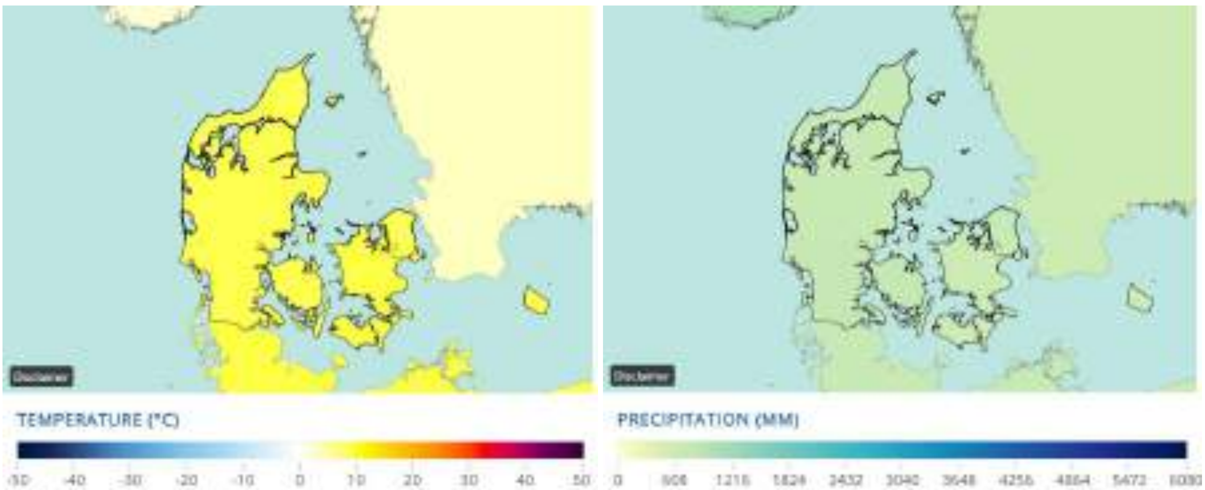
Climate

The Danish climate is temperate with precipitation evenly distributed over the year. The mean annual temperature is 8.3ºC and mean annual precipitation is 746 mm. The annual mean temperature varies from year to year, from below 6ºC to 10ºC, with an average of 8.3ºC (1981-2010 level; 8.9ºC (2006-2015 level). The coldest year so far was 1879, with a mean temperature of 5.9ºC, while the hottest recorded year was 2014, with 10.0ºC. The four years 2006, 2007, 2008 and 2014 are the warmest ever recorded in Denmark. 2008 and 2006 both had a mean temperature of 9.4°C, 2007 had a mean temperature of 9.5°C. This is followed by 1990 with 9.3°C. The temperature in January and February averages around 1ºC (1981-2010 level); around 1.3ºC (2006-2015 level) but can vary greatly from more than 15ºC to below -31ºC. The average temperature in July and August is around 16.5ºC (1981-2010); around 17ºC (2006-2015), but again can vary from -2ºC to more than 36ºC. Average annual precipitation varies greatly from year to year and from place to place. The lowest annual precipitation for the country as a whole was 466 mm in 1947, and the highest was 905 mm in 1999, while the average annual precipitation is 746 mm (1981-2010 level); 792 mm (2006-2015 level).

The wettest period is normally June to January, while the driest is February to May. In the winter months, precipitation is sometimes in the form of snow (World Bank, n.d.).



Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Denmark (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature (left) and Precipitation (right) 1991-2020; Denmark (World Bank, n.d.)

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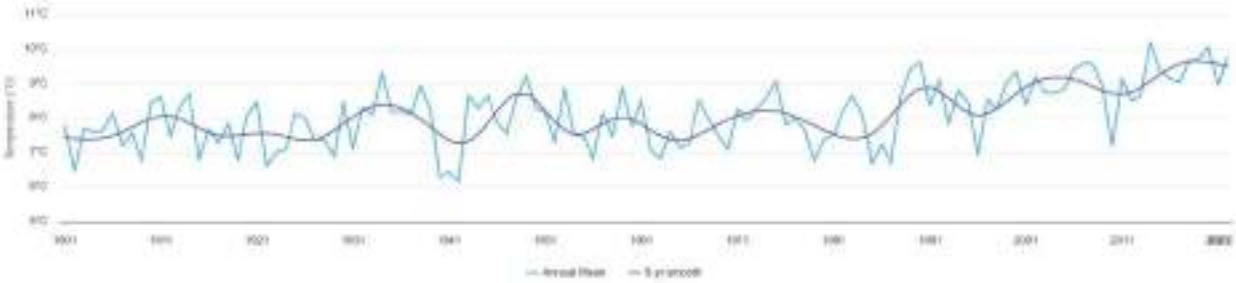
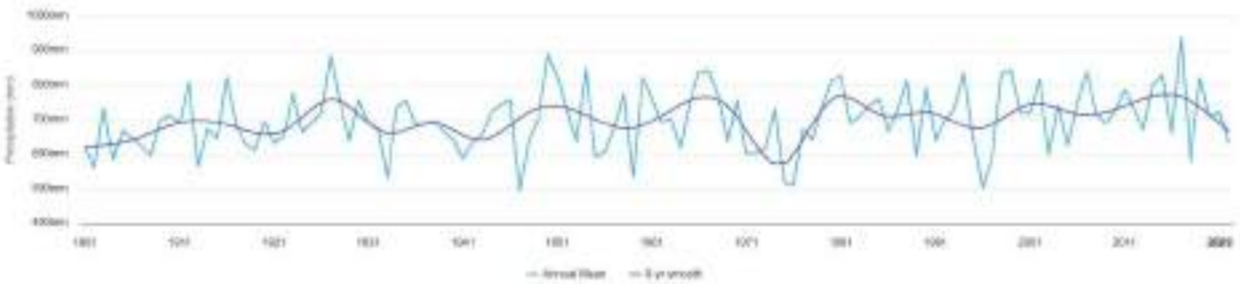


Observed Annual Average Mean Surface Air Temperature of Denmark for 1901-2022 (World Bank, n.d.)



Observed Annual Precipitation of Denmark for 1901-2022 (World Bank, n.d.)

Hydrology

Renewable water resources in Denmark total 6.1 km^3. The Skjern is the largest river in Denmark in terms of volume. It drains about one tenth of Denmark before discharging into the Ringkøbing Fjord, a bay of the North Sea near the town of Skjern. The river discharges 206 m^3/s of water into the sea. The Guden river, on the Jutland peninsula, is Denmark's longest. It flows 176 km from Tinnet Krat in Vejle County, between Nørre Snede and Tørring-Uldum, to Randers Fjord in Randers, on a course that takes it through central Jutland. On its way it traverses the lakeland waters of Sminge Sø (Lake Sminge), Silkeborg Langsø, Brassø, Borre Sø, Julsø, Biksø, Rye Mølle Sø, Gudensø, Mossø, Vestbirk Sø and Naldal Sø. In Jutland, the river Kongeå defines the border between North and South Jutland. The Kongeå rises southeast of Vejen and Vamdrup and after about 50 km flows into the North Sea north of Ribe. The Odense river is located on the island of Funen, in central Denmark. It is about 60 km long and is named after the Funish capital, Odense, which it passes by. The Vidå is a creek in Jutland, Denmark. The creek starts east of Tønder and flows to the west, ending in the North Sea. The Vidå forms part of the border between Denmark and Germany. The 83 km-long Suså River, Zealand's largest waterway and longest river, runs into Lake Tystrup, the 8th largest lake in Denmark.

Surface Water Quality and Pollution in Denmark

The majority of surface water bodies in Denmark do not meet the water quality objectives of the WFD. Good ecological status is achieved in 30% of natural surface water bodies and 17% of heavily modified or artificial water bodies. Intensive agriculture is the main driver of water pollution in Denmark, in particular diffuse source pollution of nutrients, organic matter and pesticides. Agriculture remains the largest source of pollution to coastal water in the country, and is a significant contributor to eutrophication of the Baltic Sea. Good chemical status is achieved in 57% of groundwater bodies. Groundwater quality is under threat from pollution with nitrates and pesticides from agriculture in many parts of Denmark. Good quantitative status is achieved in 65% of groundwater bodies (OECD, n.d.).

Environmental Challenges in Denmark

Denmark’s major environmental problems are: air pollution, principally from vehicle and power plant emissions; nitrogen and phosphorus pollution of the North Sea; drinking and surface water becoming polluted from animal wastes and pesticides. An urgent problem concerning groundwater is toxic leaching from waste dumps and old industrial sites. The regional authorities are actively searching for the location of these sites before serious damage is caused. Further, Danish planning rules concentrate activities with the potential for causing pollution in areas where the water resources are the least vulnerable (CEO Water Mandate, 2020).

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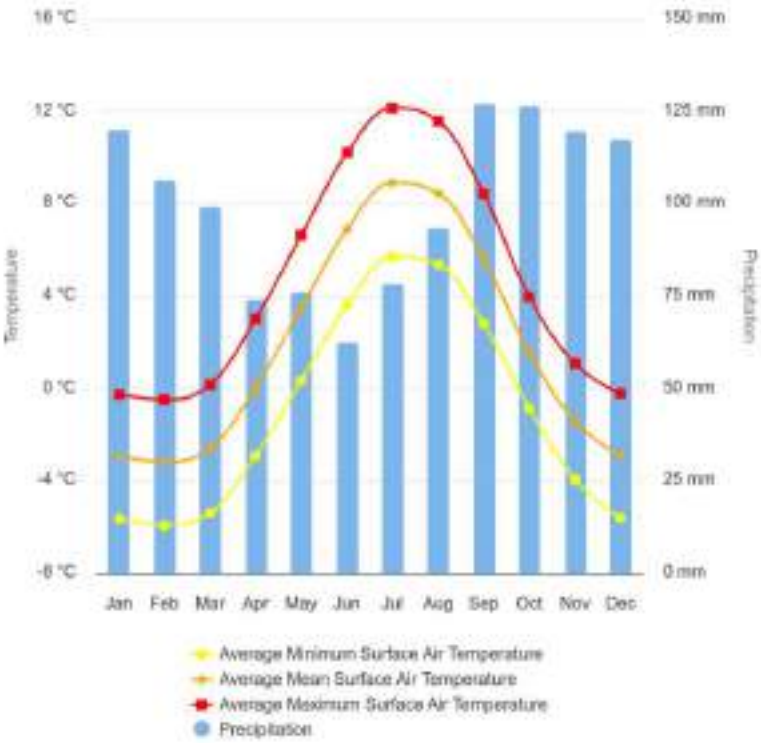
Iceland

Iceland is located in the North Atlantic between Norway, Scotland and Greenland. It is the second-largest island in Europe and the third largest in the Atlantic Ocean, with a land area of some 103,000 km^2, a coastline of 4,970 km and a 200-nautical-mile exclusive economic zone extending over 758,000 km^2 in the surrounding waters. Iceland enjoys a warmer climate than its northerly location would indicate because a part of the Gulf Stream flows around the southern and western coasts of the country. In Reykjavík the average temperature is nearly 11°C in July and just below zero in January. The population of Iceland was over 350,000 as of 2020. Iceland is the most sparsely populated country in Europe with a population density of 3 inhabitants/km^2. Settlement in Iceland is primarily along the coast. Around 63% of the nation lives in the capital area (World Bank, n.d.).

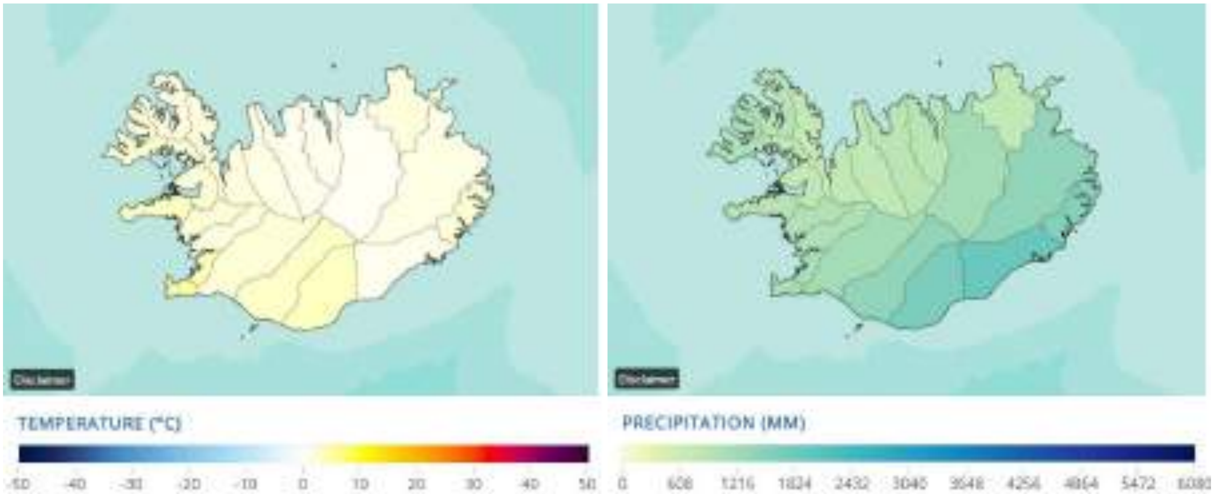
The geographical location of Iceland (Britannica, n.d.)

Climate

Iceland is situated just south of the Arctic Circle. The mean temperature is considerably higher than might be expected at this latitude. Relatively mild winters and cool summers characterize Iceland's oceanic climate. The average monthly temperature varies from -3 to +3 °C in January and from +8 to +15°C in July. Storms and rain are frequent, with annual precipitation ranging from 400 to 4000 mm on average annually, depending on location (World Bank, n.d.).



Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Iceland (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature (left) and Precipitation (right) 1991-2020; Iceland (World Bank, n.d.)

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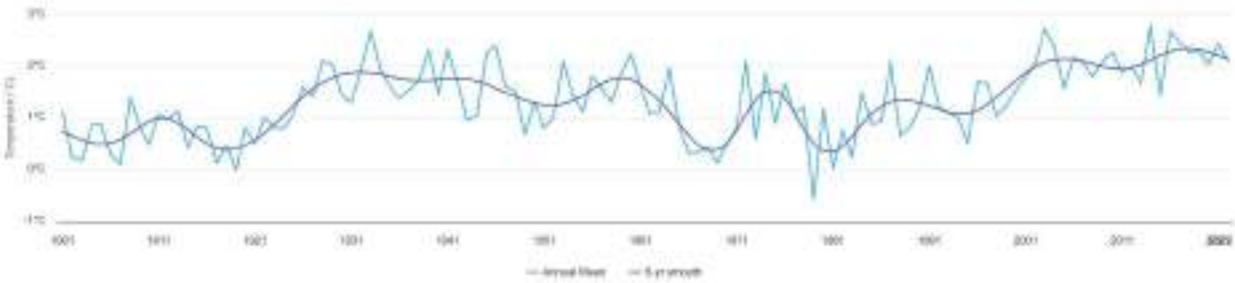
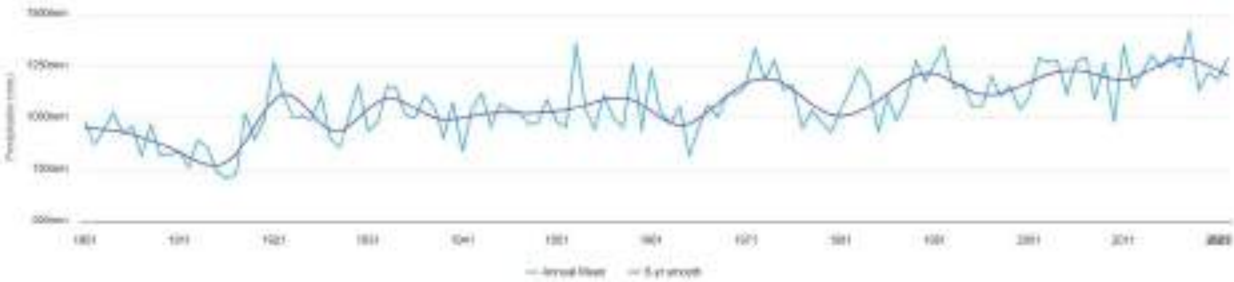


Observed Annual Average Mean Surface Air Temperature of Iceland for 1901-2022 (World Bank, n.d.)



Observed Annual Precipitation of Iceland for 1901-2022 (World Bank, n.d.)

Water quality

Iceland's environmental situation and problems differ from those of other European countries in that it has a small population which depends primarily on natural resources and their efficient and sustainable use. From an Icelandic perspective, suitable indicators for analysing its environmental performance would focus on the management of fish stocks, renewable energy sources and wilderness. However, it is important to highlight that the volcanic soils (andosols) are extremely friable and erosion is exacerbated by windy conditions over most of the country's area. Whilst birch woodland may previously have covered 25% or more of the country, currently it has been reduced to just over 1%. A third and possibly up to a half of the pre-settlement vegetation cover may now have been either lost or severely degraded. Altered vegetation composition due to grazing, cutting and burning of woodlands has resulted in reduced vegetation cover, the formation of barren lands and vegetation degradation. Decreased vegetation vigour has led to increased cryoturbation and solifluction processes that accelerate erosion. Vast areas have been desertified by over-exploitation of soil capacity (and the speed of erosion has been also magnified by volcanic activity and harsh weather conditions). The Soil Conservation Service of Iceland (SCS), founded in 1907, is one of the oldest institutes of its kind in the world, and is a governmental agency (under the ministry of Environment). The main tasks of the SCS include combating desertification, sand encroachment and other soil erosion; promotion of sustainable land use; and reclamation and restoration of degraded land. The work is carried out on different levels, from policy-making and research, to extension services and management of large- and small-scale reclamation projects. There is generally good access to good quality drinking water, especially in areas with recent lava flows where the bedrock is very permeable. There the precipitation seeps down into the ground creating large groundwater reservoirs and spring-fed rivers with very stable clear water runoff throughout the year. These waters, entirely different and much richer than the North American, Greenland and Scandinavian lakes on similar altitudes that drain old continental shield rocks, provide habitats for spectacular plant and animal communities. The productive rivers and lakes are an important amenity for recreational activities. Salmon and Country Overview - Iceland trout fisheries have been of high economic value since Iceland's initial settlement, contributing as much as 50% of the total income for residents in productive salmon areas (CEO Water Mandate, 2020).

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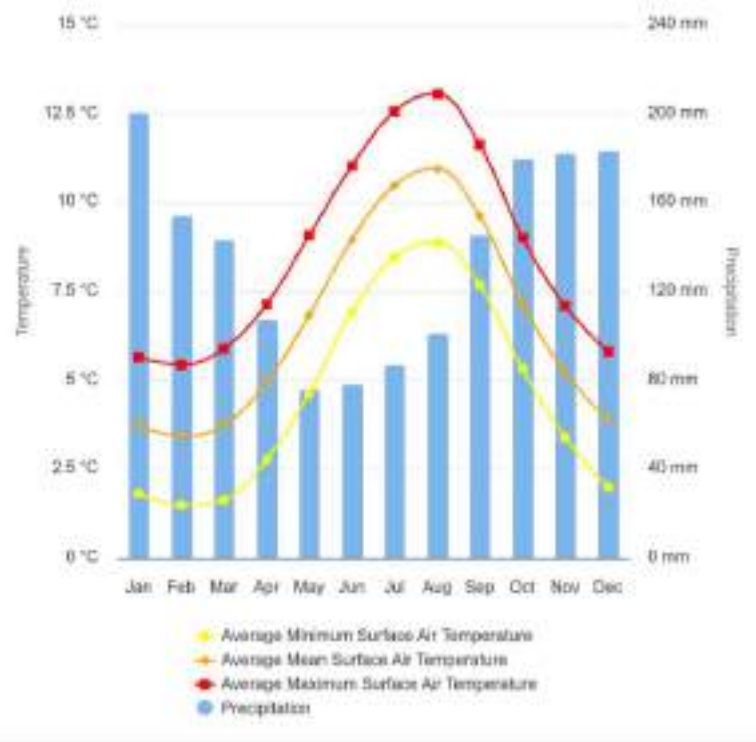
Faroe Islands

The **Faroe Islands** consist of 18 small, mountainous islands situated in the North Atlantic at about 62°N and 7°W. The islands have a total land area of 1,399 km^2 and a population over 48,000 (2020). The Faroe Islands is a modern, developed society with a standard of living comparable to other Nordic countries. However, the economy is not yet as diversified. Fishery and related industries are of such importance that their influence determines the overall performance of the Faroese economy. An economy with high dependence on fish products and exporting them is bound to be vulnerable to the changes in catches, fish prices, and exchange rates (World Bank, n.d.).

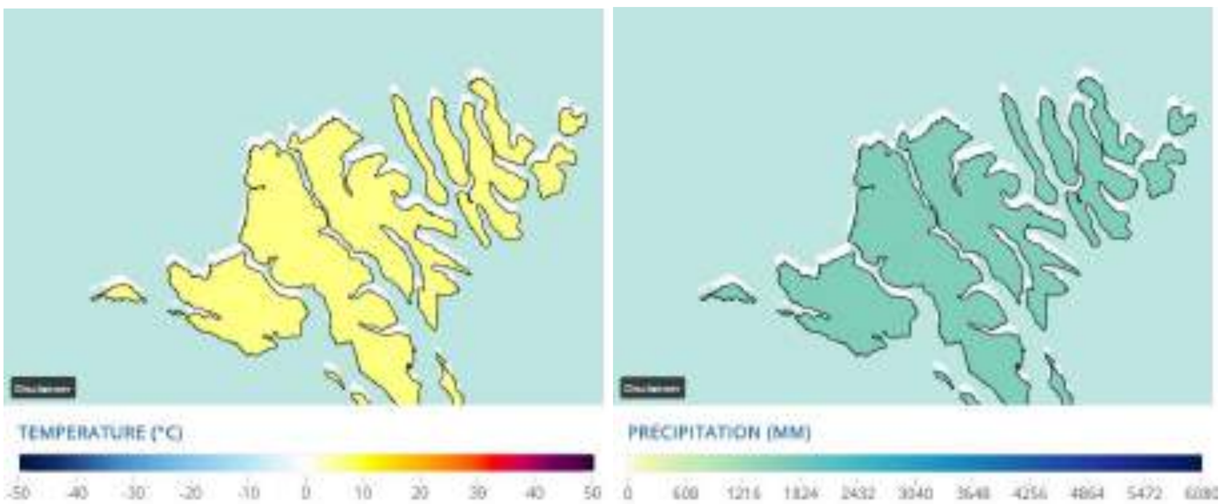
The geographical location of Faroe Islands
(Wikimedia Commons, n.d.)

Climate

The climate in the Faroe Islands is strongly affected by the warm North Atlantic current (the Gulf Stream) and frequent passage of cyclones, which, depending on the location of the polar front, mainly come from southwest and west. The Faroe Islands have an extremely maritime climate, where the differences between summer and winter are relatively small. Projections with global climate models show a rise of about 3°C in annual mean temperature, a rise in winter precipitation of about 30% and a slight increase of 10% in summer towards the end of the century (World Bank, n.d.).



Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Faroe Islands (Den.) (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature (left) and Precipitation (right) 1991-2020; Faroe Islands (Den.) (World Bank, n.d.)

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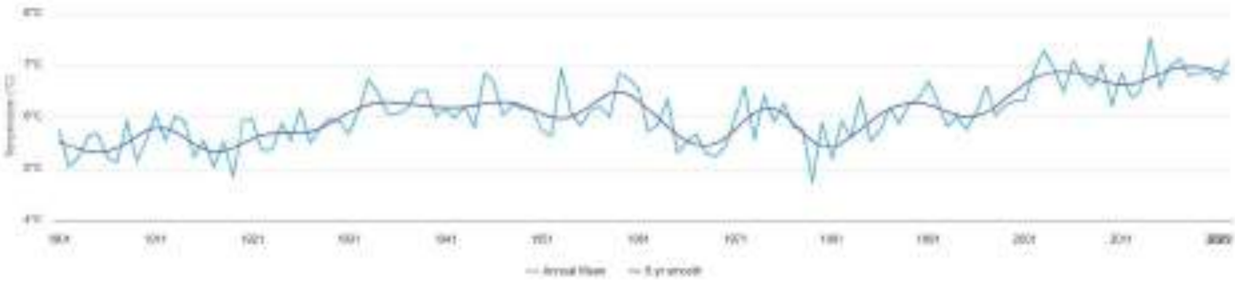
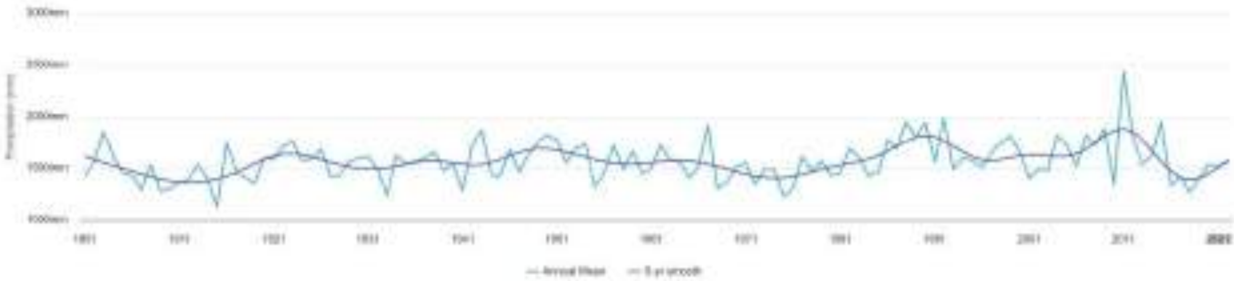


Observed Annual Average Mean Surface Air Temperature of Faroe Islands for 1901-2022
(World Bank, n.d.)



Observed Annual Precipitation of Faroe Islands for 1901-2022
(World Bank, n.d.).

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United Kingdom

The **United Kingdom** (UK) lies between latitude 49°N and 61°N and longitude 8°E and 2°W, positioned in the north western part of Europe. Around 71% (17.4 million hectares) of the total UK land area is used for agriculture (2016). The total population of the UK was estimated to be 67.2 million (2020) people, with over 83% living in urban areas. The UK economy is dominated by the service sector (79% of GDP) (2017), which has been the driver of growth in recent years. The UK is vulnerable to the impacts of climate change from extreme weather events and changes in climatic conditions, such as sea level rise and increase in temperature. Mean sea level around the UK has risen by approximately 1.4 mm/year since 1910, when corrected for land movement. Sea surface temperatures around the UK for the most recent decade (2007-2016) have been on average 0.3°C warmer than the 1981-2010 average and 0.6°C warmer than 1961-1990. These changes increase risks related to flooding, making infrastructure in the country vulnerable to a range of climate impacts (World Bank, n.d.).

The geographical location of United Kingdom (Britannica, n.d.)

Climate

The UK's climate is maritime, moist and temperate, with a moderate annual temperature range. Average annual precipitation in the UK typically ranges from approximately 800 mm to 1,400 mm. The UK climate is heavily influenced by its proximity to the Atlantic Ocean and the Gulf Stream/North Atlantic Drift which brings warm water into high northern latitudes. Prevailing winds are westerly, thus UK regional climates vary with distance from the Atlantic as well as topography. Continental influences are most strongly seen in the southeast of the country (World Bank, n.d.).

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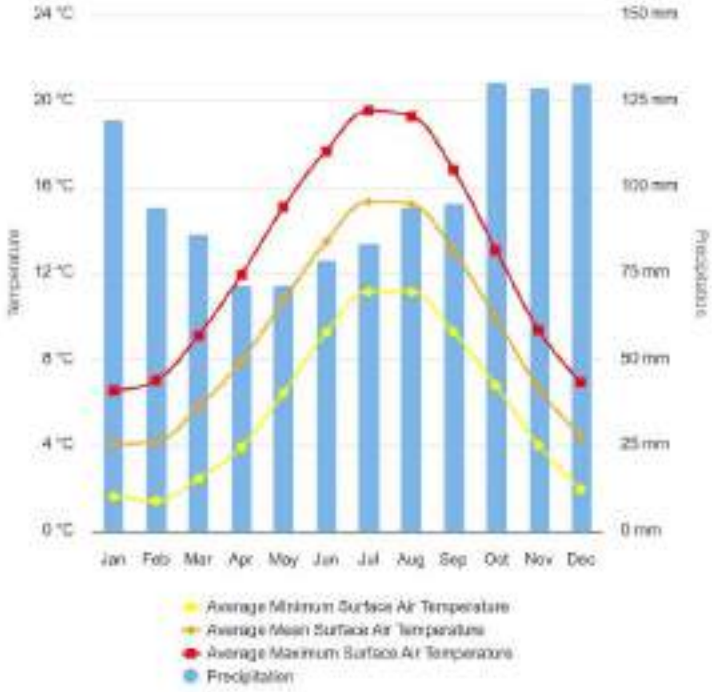
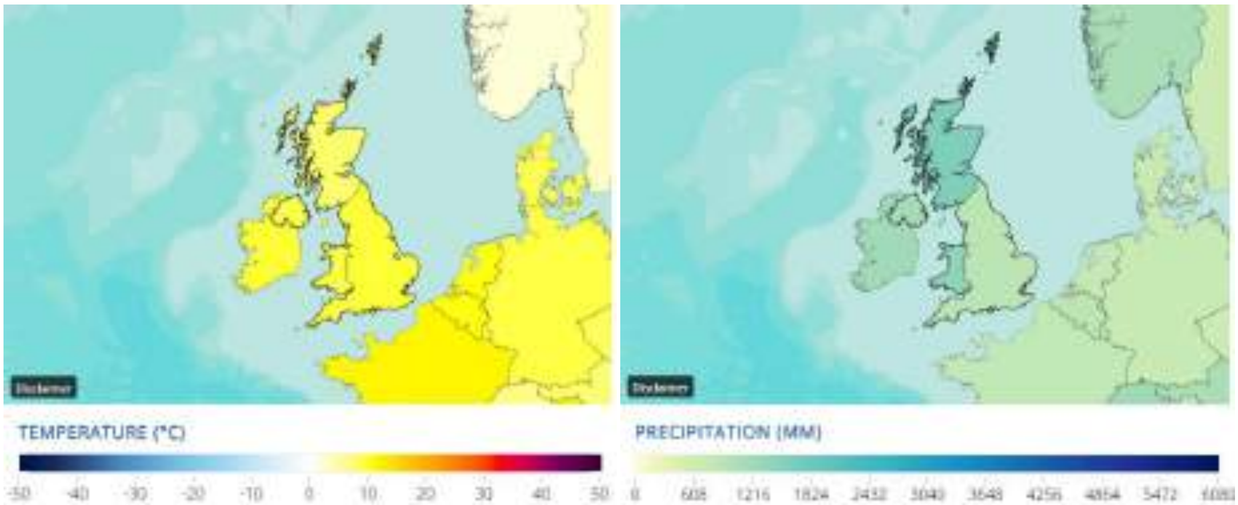


Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; United Kingdom (World Bank, n.d.)



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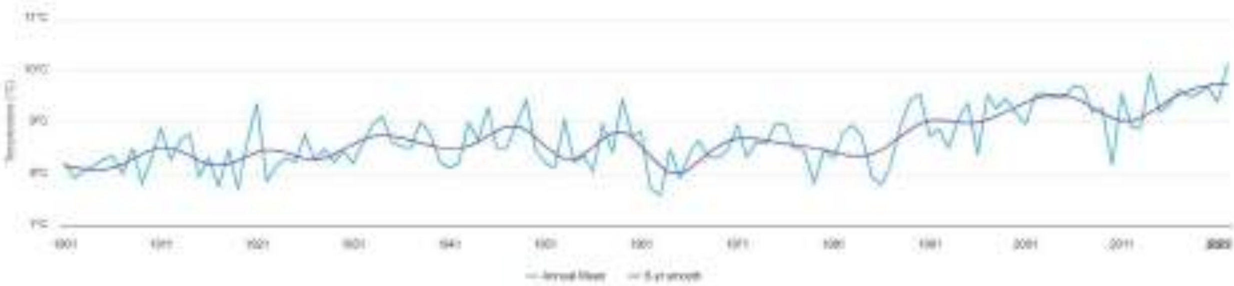
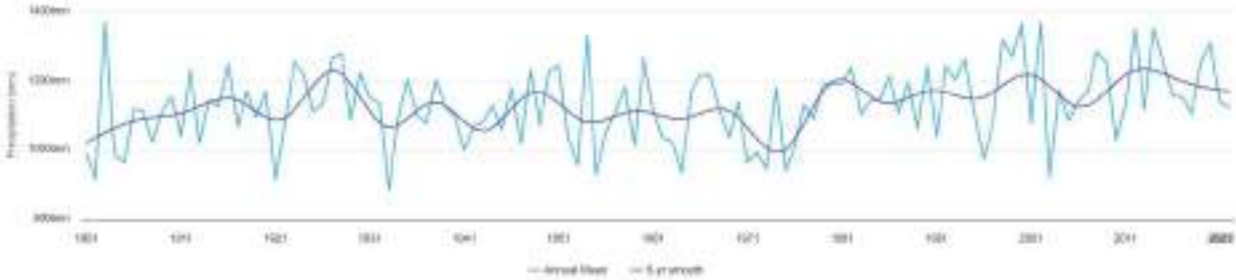


Observed Annual Average Mean Surface Air Temperature of Faroe Islands for 1901-2022 (World Bank, n.d.)



*Observed Annual Precipitation of Faroe Islands for 1901-2022 (Wor*ld Bank, n.d.)

Hydrology and water quantity

The long coastline of the British Isles compared to the land area means that the United Kingdom is dominated by numerous relatively small river systems. Only three river systems, the river Thames, the Severn and the Trent, have a catchment area exceeding 10,000 km^2, but comprise only around 7% of the total land area. England and Wales have few natural lakes, while numerous lakes (lochs) can be found in Scotland. The largest lake of the British Isles, Lough Neagh, with a surface area exceeding 300 km^2 is located in Northern Ireland. Several estuaries are located along the British coastline; the major ones being the Clyde, the Forth and the Tay on the Scottish coast, and the Severn, the Humber, the Wash, the Thames, the Mersey, the Tyne and the Tees estuaries on the English and Welsh coast. The major seas surrounding the British Isles are the North Sea to the east, the English Channel to the south, Bristol Channel, St. George Channel, the North Channel, the Irish Sea and the Atlantic Ocean to the west (European Environment Agency, n.d.).

Water quality

The provision and management of water resources is critical to our health, social and economic wellbeing. However, pollution and flooding can cause significant economic, social and environmental damage. In addition, pressures are being exerted on water quality and our water resources such as climate change, high population densities, and land use patterns (Government of the United Kingdom, n.d.). The main reasons for poor water quality are: excessive use of fertiliser and pesticides in agriculture – identified as being responsible for 40% of water pollution in England, untreated sewage released by water companies – responsible for 35%, so-called “run-off” from roads and towns which contains pollutants such as oil – responsible for 18%. But Professor Steve Ormerod, ecologist at Cardiff University, also warns of other threats: “We need to understand the risks which come with emerging pollutants – pharmaceuticals, microplastics. We don’t know, at this stage how big a problem they’re going to be in the future.” Previous campaigns on acid rain and sewage have been successful in improving water quality, but improvements have stalled since 2016 (Institute of Fisheries Management, n.d.). Storage across the seasons becomes the main problem, particularly when extended periods of summer drought will increase demand for domestic and agricultural irrigation as well as commercial and industrial use. The quality of water is also of concern as river flows reduce and pollutants increase. As with public water supply, the potential increase in demand for water depends on social and technological change. In terms of spray irrigation, the Environment Agency demand projections study concluded that this component of demand could decrease by up to 20% or increase by 50% by 2025, depending on the different scenario assumptions of customer and supermarket produce quality demands, international competition, and crop varieties. London is one of the driest capital cities in the world, with available water resources per head of population similar to that of Israel. Climate change could reduce the amount of water available and increase demand in summer. Lower river flows in summer will raise water temperatures and aggravate water quality problems in the Thames and its tributaries,

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especially following summer storms. London may also be particularly sensitive to increases in temperature in the future because of the urban heat island effect. In general, water is plentiful in Scotland. Summer flows of rivers have generally declined throughout Scotland, but not sufficiently to generate significant change. Higher winter rainfall and wetter catchment conditions are likely to result in higher frequency of floods in winter. The authorities tend to start the year with full reservoirs so extra rainfall is not necessarily useful. Slightly higher precipitation without extreme variability, as suggested in the climate scenarios, will continue to ensure a plentiful supply of high quality water to Scotland. In addition, higher precipitation will also ensure the dilution of effluents through higher river flows (Climate Change Post, n.d.).

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Norway

Norway is located in Northern Europe. It shares borders with Sweden, Finland, Russia, the North Sea and the North Atlantic Ocean. Norway has a total area of 323,781 km2 and a mainland coastline of more than 2,500 km long, excluding fjords and bays. With approximately 5.4 million (2020) inhabitants, Norway has the lowest population density in Europe after Iceland. The large majority of the Norwegian population is settled along the coast and the fjords, and an increasing percentage, about 80% of the population lives in urban settlements. Norway is a small, open and integrated economy. The petroleum industry has for several decades been a key driver for economic growth in Norway. In 2016, the production of crude oil and natural gas accounted for 15% of the Norwegian GDP. The service sector (private and public) accounted for 65% of GDP and over 75% of employment in 2017. Norway is vulnerable to the impacts of climate change such as increase in annual mean temperature and precipitation, rainfall floods, summer droughts, sea level rise, and ocean acidification. The natural environment, infrastructure and buildings, in particular water and sewage, are particularly vulnerable to climate change in Norway (World Bank, n.d.).

The geographical location of Norway (Britannica, n.d.)

Climate

Most of Norway has a maritime climate with mild winters and cool summers. Because of the influence of the North Atlantic Ocean, Norway has a much warmer climate than its latitudinal position would indicate. On an annual basis, the highest normal (1961-1990) annual air temperatures (up to 7.7°C) are found along the south-western coast. Outside the mountain regions, the lowest annual mean temperatures (down to -3.1°C) are found on the Finnmark Plateau. The absolute lowest and highest temperatures measured at official weather stations on the mainland are -51.4°C and +35.6°C, respectively. Because of the prevailing westerly winds, moist air masses flow regularly in from the ocean

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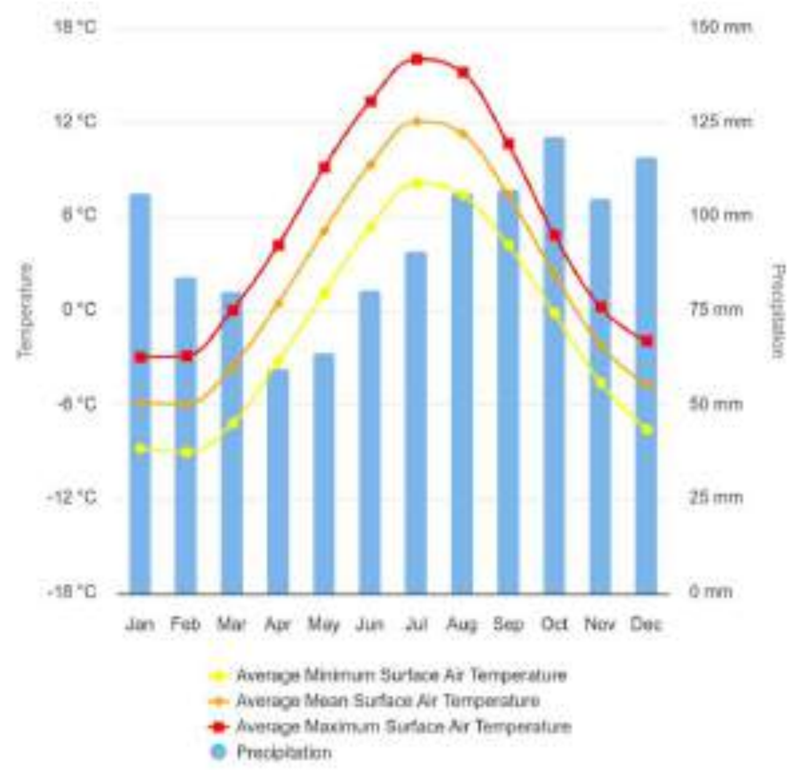
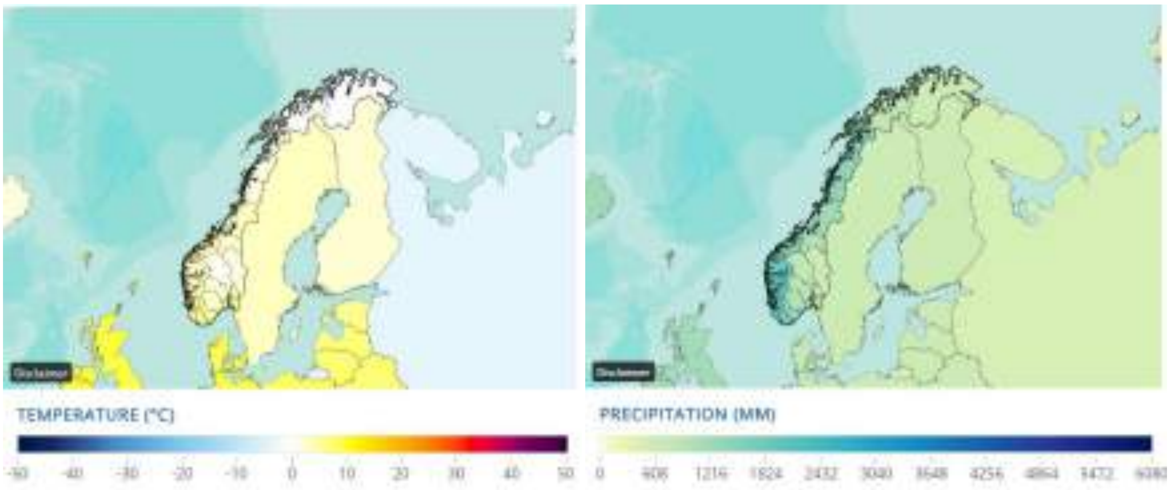
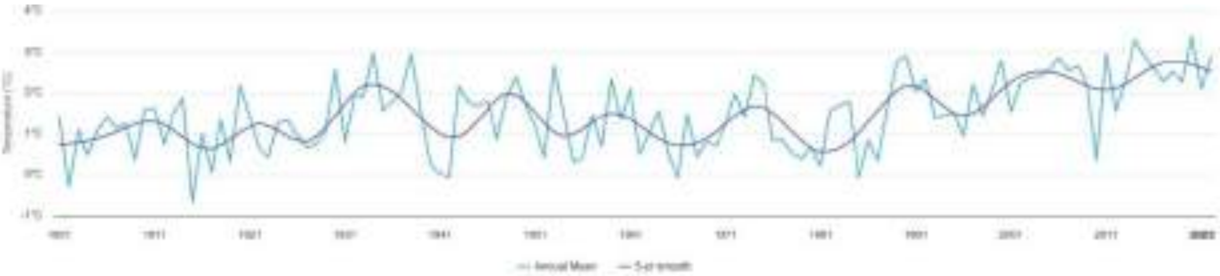
giving abundant precipitation over most of Norway. Areas just inland from the coast of western Norway experience the most precipitation. This zone of maximum precipitation is one of the wettest in Europe, and several sites in this region have normal annual precipitation of more than 3,500 mm (World Bank, n.d.).



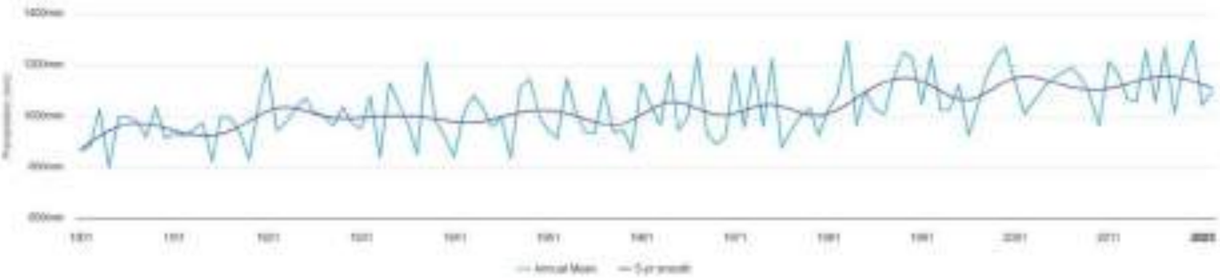
Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Norway (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature (left) and Precipitation (right) 1991-2020; Norway (World Bank, n.d.)



Observed Annual Average Mean Surface Air Temperature of Norway for 1901-2022 (World Bank, n.d.)



Observed Annual Precipitation of Norway for 1901-2022 (World Bank, n.d.)

Water quality

Although most fresh water is of satisfactory quality, the government has during the last 15 years been encouraging water works to increase the proportion of groundwater in drinking water supplies for environmental reasons, to cut costs and to reduce the risk to public health from contamination. Special restrictions on land use are used to protect drinking water sources from pollution. Financial compensation is provided where such restrictions are in force. Norway has built several wastewater treatment plants with secondary treatment (chemical purification) over the last few years, and a secondary phase is planned for all treatment plants with a hydraulic capacity of more than 2,000 population equivalents that discharge treated water to freshwater recipients. Acidification is still a serious problem in Norway, and causes fish deaths and corrosion problems. 90% of the pollution that causes acidification originates abroad. The Convention on Long-Range Transboundary Air Pollution is now sharply reducing it (CEO Water Mandate, 2020). In general, water is relatively abundant with a total freshwater resource across Europe of around 2270 km^3/year. Moreover, only 13% of this resource is abstracted, suggesting that there is sufficient water available to meet demand. In many locations, however, overexploitation by a range of economic sectors poses a threat to Europe's water resources and demand often exceeds availability. As a consequence, problems of water scarcity are widely reported, with reduced river flows, lowered lake and groundwater levels and the drying up of wetlands becoming increasingly commonplace. This general reduction of the water resource also has a detrimental impact upon aquatic habitats and freshwater ecosystems. Furthermore, saline intrusion of over-pumped coastal aquifers is occurring increasingly throughout Europe, diminishing their quality and preventing subsequent use of the groundwater. Virtually all abstraction for energy production and more than 75% of that abstracted for industry and agriculture comes from surface sources. For agriculture, however, groundwater's role as a source is probably underestimated due to illegal abstraction

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from wells. Groundwater is the predominant source (about 55%) for public water supply due to its generally higher quality than surface water. In addition, in some locations it provides a more reliable supply than surface water in the summer months (Climate Change Post, n.d.).

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Austria

Austria is a land-locked country located in southern central Europe, between 49°01' and 46°22' N and from 9°32' to 17°10' E, covering part of the eastern Alps and the Danube region. Austria's total surface area covers 83,858 km^2 with a share of 37.5 % settlement area. Austria's total permanent population reached 8.9 million inhabitants in 2020, and nearly one-third of all Austrians (2.6 million) live within the metropolitan area of Vienna. Austria is expected to be very vulnerable to climatic change given that its ecosystems in mountainous regions are highly sensitive, and approximately 70 % of Austria's surface is situated higher than 500 m above sea level. Austria can be divided into three climatic zones: the eastern part shows a continental Pannonian climate (mean July temperature >19°C, annual rainfall Nationally Determined Contribution (NDC) to the UNFCCC as an EU Member State in 2020, and its Seventh National Communication in 2018.

The geographical location of Austria

Climate

Austria belongs to the central European transitional climatic zone; the climate is crucially influenced by the Alps, which are situated in a transitional area of the Mediterranean, the Atlantic Ocean, and continental Europe. Austria can be divided into three climatic zones: The eastern part shows a continental Pannonian climate (mean temperature for July usually above 19°C, annual rainfall often less than 800 mm), while the central Alpine region has the characteristic features of the Alpine Climate (high precipitation, short summers, long winters). The remaining part of the country belongs to the transitional central European climatic zone, which is characterized by a wet and temperate climate. As Austria is a country with highly structured relief, a lot of small-scale climatic processes occur caused by orographic conditions.

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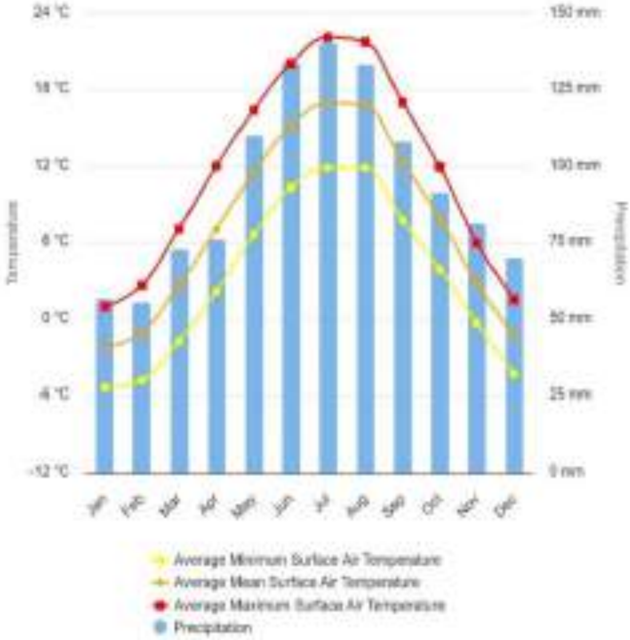
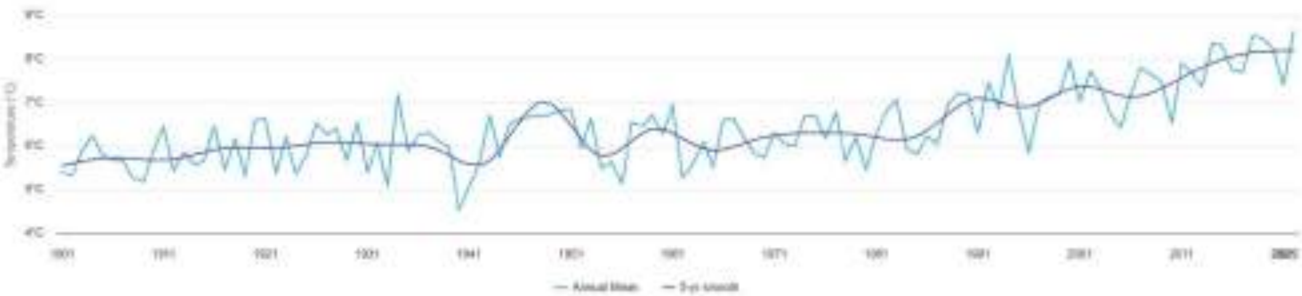


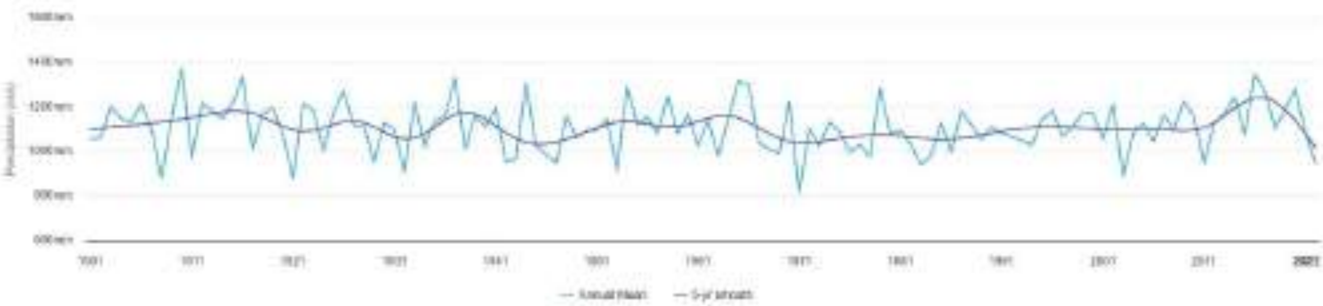
Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Austria

Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Austria



Observed Annual Average Mean Surface Air Temperature 1901-2022; Austria

Observed Climatology of Precipitacion 1991-2020; Austria



Observed Annual Precipitation 1991-2020; Austria

Hydrology

The annual precipitation average is 1,170 mm, which corresponds to a precipitation volume of some 100 billion m^3 per annum. About 55 billion m^3 of this rainwater runs off into water bodies, whereas 45 billion m^3 simply evaporates into the atmosphere. The above figures determine the hydrological balance for the period 1961 to 1990. The Danube is a major economic, geographical, and cultural force in Austria. Draining over 96 % of the country's territory, the basin is home to 7.7 million people. In a country dominated by the Alps, the flat lands provided by the rivers are of huge significance for agriculture, human settlements, and infrastructure. The Austrian territory accounts for 10 % of the total area of the Danube Basin. The major rivers north of the watershed of the Austrian Alps (the Inn in Tyrol, the Salzach in Salzburg, and the Enns in Styria and Upper Austria) are direct tributaries of the Danube and flow north into the Danube valley, whereas the rivers south of the watershed in central and eastern Austria (the Gail and Drau rivers in Carinthia and the Mürz and Mur rivers in Styria) flow south into the drainage system of the Drau, which eventually empties into the Danube in Serbia. Consequently, central and eastern Austria are geographically oriented away from

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the watershed of the Alps: the provinces of Upper Austria and Lower Austria toward the Danube, and the provinces of Carinthia and Styria toward the Drau. Essential water reserves are found in the karst terranes of Northern and Southern Kalkalpen. About one-quarter of the total precipitation falls in this area, which covers 20 % of the national territory of Austria. About 15 % of the federal territory is covered by the alternately permeable tertiary rock formations of the pre-Alpine region. The remaining 20 % of the national territory is covered with Pleistocene and Holocene sediments, found in the pre-Alpine region and in the valleys and basins of the Alps with, in some areas, enormous pore water resources.

Water quantity

About 84 billion m^3 of water is available to Austria per year. Austria's total annual water demand amounts to 2.6 billion m^3, which is equal to approximately 3% of the renewable quantity of water. More than two-thirds thereof is accounted for by industry, 35 % is required for drinking water, and 5 % is needed in agriculture. However, apart from these direct abstractions, water is also utilized in many other ways, for example, as a source of energy: 65 % of the demand for electricity is covered by hydroelectric power plants. Water has also become an indispensable factor in tourism.

On average, every Austrian consumes about 150 L of water daily (not including trade, industry, or large-scale consumers). If we take into account companies as well, this quantity rises to 260 L/day. These figures have remained about the same for many years. The use of water-saving production processes and technologies, the increased recycling of used industrial water, and the consistent elimination of water losses in the water piping system and in households have led to the decoupling of economic growth and water consumption.

The industry is Austria's largest consumer of water. It accounts for almost two-thirds of the entire demand for water (including cooling water). The most recent survey of water consumption by the industry was conducted in 1994 within the framework of the Austrian Industriestatistik (Industrial Statistics). The sector with the highest share in the total consumption of water is the iron and steel industry (41.5 % of the total consumption), followed by the chemical industry (28.5 %), the paper industry (15.6 %) and the food industry (3.6 %). In agriculture, about 50 % of the required water is needed for watering and 50 % for animal husbandry.

Water quality

Austria's major environmental problems include forest degradation caused by air and soil pollution; the soil pollution results from the use of agricultural chemicals; and air pollution from emissions by coal- and oil-fired power stations and industrial plants and from trucks transiting Austria between northern and southern Europe. The water quality of Austria's water bodies is, for the most part, very good. Measures taken to remove the organic and chemical pollutants from industrial and municipal sources have generally been successful. Investments in wastewater purification have thus been worthwhile. Hazardous substances have been detected only very rarely. Regarding organic pollution and nutrient pollution, about 80 % of the water network studied complies with the criteria for 'good' status. Less favourable is the situation of the river structure (hydromorphological situation). For approximately 56 % of the assessed network of running waters, assessment indicates that 'good' status has not been achieved. Similar figures have been determined in many other European countries. In most cases, these problems have a historical cause, namely the utilization of water power and protection against flooding, as well as the establishment of agricultural production areas. Studies were conducted on intensively built-up waters to determine whether the restoration of the good ecological status could have negative impacts on existing utilizations. These waters include 44 % of the running-water stretches that were examined. They were provisionally identified as 'artificial or heavily modified' waters. To such stretches of water, lower quality requirements will apply.

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Slovenia

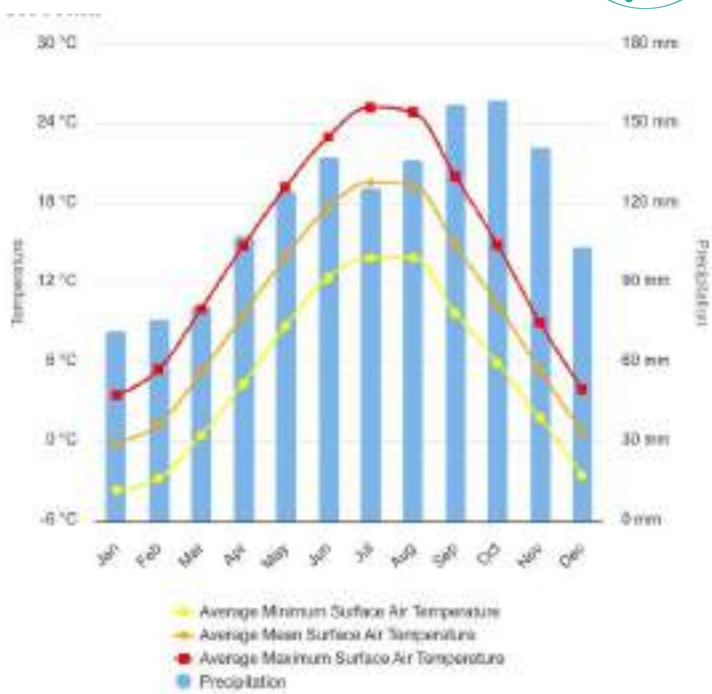
Slovenia is located in Central Europe. The surface area of the territory is 20,273 km^2, and its coastline length is about 46 km. Slovenia shares borders with Austria in the north, Hungary in the east, Croatia in the south, and Italy in the west.

The geographical location of Slovenia

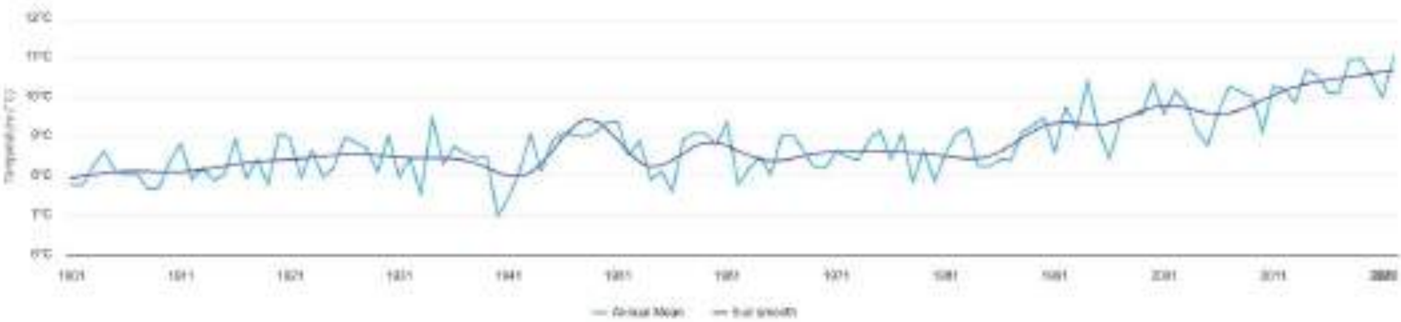
Climate

Three climate types are found in the territory of Slovenia: sub-Mediterranean, Alpine, and continental. Average annual temperature in the sub-Mediterranean climate type is 12°C, in the lower regions of central Slovenia it is between 8°C and 1°C, while at the highest peaks it never exceeds 0°C. Annual precipitation varies to a great extent, from 800 mm in the extreme north-eastern and 1000 mm in the extreme south-western part of the country to over 3000 mm in the north-western part of the country.

Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Slovenia



Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Slovenia



Observed Annual Average Mean Surface Air Temperature 1901-2022; Slovenia

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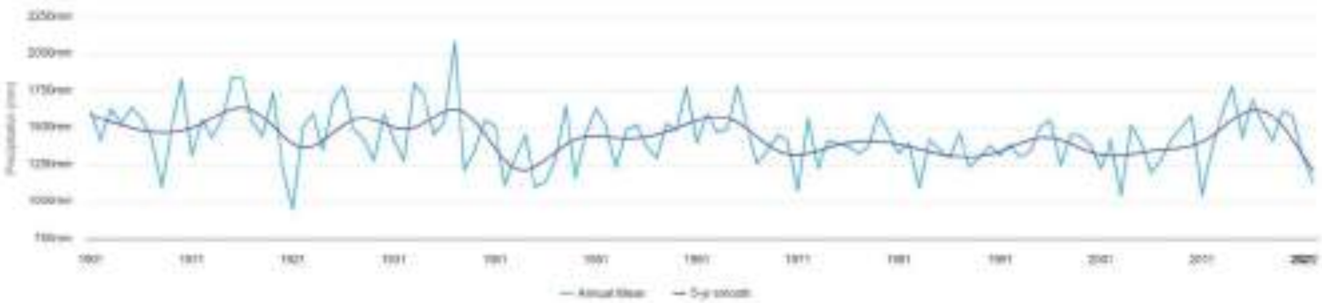
Observed Annual Precipitation 1901-2020; Slovenia



Observed Annual Precipitation 1901-2022; Slovenia

Hidrology

Slovenia ranks among the better-watered and largely spring-fed countries, with a dense river network, a rich aquifer system, and significant karstic underground watercourses. Slovenia has a moderately warm climate. However, in line with its geographical diversity, conditions vary. Meeting above Slovenian territory are the influences of the Mediterranean climate, which is characteristic of the coastal part of Slovenia; the continental climate typical of the central part of Slovenia and the Pannonian region to the east and the Alpine climate in the northwest of the country. The level of precipitation is sufficient across most of Slovenia, and does not vary seasonally. It is highest in the Alpine area to the west, with more than 3,000 mm/yr, and this declines to the east, where it is lowest, amounting to around 800 mm/yr. Along the Adriatic coast the precipitation level is lower than the average and lower in summer than in winter. In winter it is normal for snow to cover all continental regions, and in the Alps – given the high amounts of precipitation – the snow cover can reach up to 9 m. In the summer, especially in June, July and August, the greater part of Slovenia typically experiences a large number of storms, around 50 each year – the highest amount in Europe. It has a long-term average annual precipitation of 1,162 mm/yr. The long-term average of annual renewable water resources is 31,870 million m^3/yr of which 59 % of them are considered as internal water resources, and (18.670 million m^3) and 41 % are considered as external water resources (13,200 million m^3).

Analyses of the hydrological state in Slovenia indicate that the available quantities of water are diminishing and that the distribution of precipitation is changing in terms of time and space. Greater regional difficulties are anticipated due to the following effects of climate change: greater frequency and strength of hydrological, meteorological, and geomorphological natural threats, droughts, heat waves, storms, high winds, frosts, hail, and fires in the natural environment due to temperature extremes, a change in precipitation and flow regimes and a deterioration in the ecological and chemical quality of water. The anticipated climate change is contributing to the reduced availability of water and also to the more frequent and longer-lasting spring and summer droughts. In Slovenia drought accounted for more than 80 % of the damage from natural disasters in 2003, 70 % in 2000 and 60 % in 2001. Agricultural drought was also encountered in 2006 and 2007. Owing to climate change – rising temperatures and increased evapotranspiration, less and more imbalanced precipitation in terms of timing and location, increased frequency and intensity of extraordinary weather phenomena, etc. – there will be a heightened role for Slovenian agriculture and forestry in ensuring environmental and ecosystem services.

Farm and forest management must also play a major part in efficient water use in drought-prone areas, in the protection of watercourses from excessive emissions of nutrients, in support of creating the conditions to ensure clean drinking water, in improving the control of floods and other natural disasters, in preserving and increasing the numerous functions of the forests, and in maintaining and renewing multi-purpose landscapes. The construction of dams and irrigation systems ranks among the most important objectives of agricultural policy. This also includes long-term planning and construction of irrigation systems with the adequate provision of new water sources and the prudent conservation of existing ones. Climate change projections indicate that without any adaptation, it will be impossible to maintain farming in the most vulnerable areas, while yields and competitiveness will be reduced in other areas. On average, there are sufficient quantities of water in Slovenia, and most of it is in a good ecological state. There is a noticeable impact of agriculture on water quality, especially in the eastern parts of the country, which are dryer. There is also a concern about the decreasing of groundwater levels in certain areas. Estimates of the quantity of groundwater bodies provided by the hydrogeological service of the Slovenian Environment Agency (ARSO) point to a relatively good situation, although concern has risen in recent years over the lowering surface level of certain parts of groundwater bodies. In the future, because of possible unfavourable developments owing to climate change, this phenomenon will be closely monitored. Nevertheless, since 1992, a total of seven summer droughts have hit agriculture. The drought accounted for 80 % of the total damage incurred from natural disasters in 2003. At least 15 % of the country's surface area is threatened by a lack of water in the soil in summer months, most of all the Primorska region and northeast Slovenia. In observing climate change there has been a noticeable shift towards a serious lack of water in the interior of the country, too. The summer of 2003 saw the consequences of the uneven distribution of water resources in Slovenia and, in places, also the weakness of the supply of drinking water, with 47,396 people – 2.4 % of the population – needing to be supplied with water brought in by tankers. Despite reserves in the Alps, the most favourable scenarios indicate that water shortages may be expected in the northeastern parts of the country. Floods threaten more than 3,000 km^2 or just fewer than 15 % of the country's surface area. As much as half the flood zone is in the Sava basin, 40 % in the Drava basin and 4 % in the Soča basin. There is a threat primarily to flash-flood ravines, valley floors and, in many places, built-up alluvial plains. There is less extensive flooding from coastal tides and karstic flooding. In part of the flood areas, grassland and pasture have been converted to cultivated land, and in some places, flood areas have also been built on. In 1991, the area of usual flooding was home to 7 % of the population, a quarter of whom live in areas affected by major floods.

Water quantity

The anticipated climate change is expected to contribute to the reduced availability of water due to increased use in agriculture and the energy sector. Data on water abstraction in Slovenia has been reliable since 2002 when the Waters Act laid down the acquisition of water rights for any special use of water. In 2008, around 40,400 legal entities and individuals acquired rights to make special use of water. The main water consumer is hydroelectric power generation,

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followed by one of the nonhydroelectric power generation sectors (electricity generation in thermal power stations). Other uses – irrigation, snowmaking, beverage production, etc. – represent a small proportion of consumption, but they are growing. Statistics on the quantity of water pumped into the mains water system for use in households and manufacturing indicate a reduction in the last decade, primarily due to more efficient use of water in the industry – thanks to the impact of taxes payable for burdening water – and farming. Household consumption of water has not changed significantly. Water withdrawal in the country in 2009 was estimated at a total of 942 million m^3. Around 80 % of the total resources abstracted come from surface water bodies, and around 20 % come from groundwater bodies. This water abstraction can be itemized by user sector. In 2009, it was estimated that the water dedicated to agriculture only reached the mark of 2 million m^3. For Urban purposes, the water abstraction was stated as 165 million m^3, and for industrial uses, the value was stated as much as 775 million m^3 (more than 80 % of the total demand).

Water quality

Water quality is especially impacted by agriculture, so great attention is paid to agri-environmental measures. The state strives, as far as it can, to achieve the goals of environmental policy, these being to ensure the sustainable exploitation of the country's aquatic wealth to improve the state of its ecology where it is still not good, and conserve it where it is. More than half the population's wastewater is treated in municipal or communal facilities. Karstic water merits special concern, owing to its vulnerability and meagre capacity for self-purification. Since such water supposedly accounts for almost half of Slovenia's reserves of groundwater, its protection is especially important. Caution is desirable across the entire area of the karst since many routes of underground watercourses remain unexplored. However, the majority of Slovenian water bodies meet international goals for water quality. There are programs for improving and maintaining water quality in implementation and trevisions in preparation. The Slovenian Environment Agency started implementing the monitoring programs under the Water Framework Directive (WFD, Directive 2000/60) in 2007. Of 121 surface water bodies in the Danube drainage area, 100 were classified, with 44 not matching the objectives; 2 of 44 were classified as very poor, 6 as poor, and 36 as of moderate quality. The remaining 56 water bodies achieve the environmental objectives, with 49 being classified as good and 7 as being of very good environmental quality. Of 34 water bodies in the Adriatic drainage area, 28 surface water bodies were classified. Of these, five do not achieve the objectives set out in the WFD; one of five is classified as poor and four as of moderate quality. The remaining 23 water bodies achieved the environmental objectives, with 19 being classified as good and 4 as being of very good environmental quality (based on the information stated by the RBMPs). Slovenia's objective is to achieve overall good water quality by 2020 at the latest. The three biggest natural lakes have been assessed. Account has been taken of the biological elements of quality, general physical and chemical parameters and special contaminants, but not of fish, since as in the case of rivers, an evaluation methodology has not yet been formulated. Lake Bohinj has been classified as being in very good ecological condition, and Lake Cerknica is in good. The reason for the moderate quality of Lake Bled is the excessive burden of nutrients. At Lake Bled, an improvement in quality, mainly the result of measures taken, has been observed. The average concentration of phosphorus, however, is much higher in artificial retention lakes in central and northeast Slovenia that lie in areas of intensive farming. Point sources of water pollution cause problems chiefly during periods of low flow of watercourses and when legally established emission values are exceeded. However, it is harder to exercise control over diffuse sources of emissions into surface and groundwater. There are difficulties in removing wastewater from settlements where sewers and treatment facilities are not yet properly in place, and these are compounded by nutrients from plant protection agents used in agriculture. In the Danube drainage area, the calculated total annual emissions in 2003/2004 amounted to 6,339t/yr of nitrogen and 27 t/yr of phosphorus, while in the Adriatic drainage area in the same period, annual emissions were 641t/yr of nitrogen and 3 t/yr of phosphorus. Slovenian rivers are fast-flowing, so they possess good oxygen conditions and few nutrients. The concentration of nitrates is slightly above the natural background, estimated at 1mg N/L (4.4mg NO_3/L). Average concentrations are lower than 10 mg NO_3/L, with higher amounts apparent in northeast Slovenia, although for the most part, they do not exceed 40 mg. No major seasonal variations have been observed. The water bodies most affected by human activity are in the northeast of Slovenia. A three-year data series indicates, with a high level of reliability, the poor chemical condition of the Savinja, Drava, and Mura basins and, with a low level of reliability, the eastern Slovenske gorice area. Of pesticides, the concentrations of atrazine are most commonly exceeded, although concentrations in groundwater are falling. Generally speaking, the rivers and lakes are not burdened with hazardous substances. The assessment of the chemical condition for 2006-2008 indicates that only two bodies of inland water did not achieve good quality, owing to excessive concentrations of mercury and tributyltin compounds, respectively. The proportion of the population whose wastewater is treated in municipal or communal treatment facilities rose from barely a fifth in 1998 to almost half in 2007. 65 % of a total of 111 million m³ of treated wastewater attained a secondary level of treatment in these facilities in 2007. Even though, compared to other European countries, the proportion of inhabitants connected to the wastewater drainage system is low, this is largely a consequence of the scattered settlement of Slovenia. The Operational Program for Removal and Treatment of Wastewater for 2005-2017 envisages the construction of a system of public sewage and municipal water treatment plants. By the end of 2017, more than 1.5 million, or 75 %, of Slovenia's inhabitants will be connected to the public sewer system. The operational program for drinking water supply up to 2013 sets the objective of ensuring a safe drinking water supply for everyone. In the event of microbiological pollution, there is a need to adhere consistently to the principles of multiple barriers and to prepare drinking water where necessary. In the event of chemical contamination – pesticides and nitrates– measures need to be taken in water protection areas. Polluted small systems need to be corrected or closed down, and residents are connected to medium and large-scale systems.

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Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy

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Croatia

The Republic of Croatia belongs to the Adriatic-Mediterranean and Pannonia-Danube group of countries in Central Europe. The total area of Croatia is 87,661 kilometers square (km^2), with a land area of 56,594 km^2, territorial sea and internal sea waters account for 31,067 km^2.

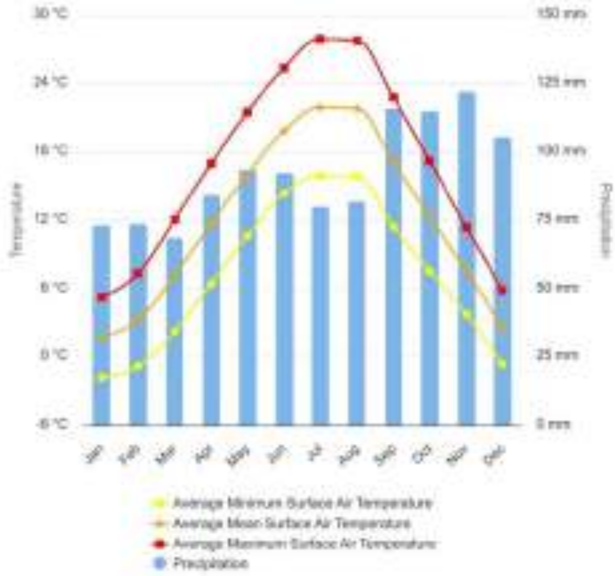
The geographical location of the Republic of Croatia

Climate

The majority of Croatia experiences a moderately warm and rainy climate. Mean temperature in the lowland area of northern Croatia is 10°C–12°C, the mountain regions experience mean temperatures of 3°C–4°C, with coastalare as experiencing temperatures of 12°C–17°C.

Most of the precipitation is recorded on the coastal slopes and peaks of the Dinarides from Gorski Kotar in the northwest to the southern Velebit in the southeast. Croatia is defined by three major geomorphological zones: the Pannonian basin, the mountain system of the Dinarides, and Adriatic basin. The Lowland areas, up to 200 m, represent 53 % of the area of the country, hills, and sub-mountains from 200 up to 500 m represent 26 %, and mountain areas above 500 m equate to 21 % of the country. As of 2011, 23 % of the land area was used by for agriculture, and forests covered 39 % of the land area. Croatia is a climatically complex area and has experienced a large variability in precipitation trends across the country over the last decades. Particularly, the mountainous region and the coastal zones are mostly affected by drying tendencies in precipitation, especially during the summer season (May to October), while the mainland is subjected to wetter precipitation conditions. The reduction in annual amounts of precipitation in the area north of the Sava River results from a decline in spring and autumn precipitation. In the mountains and on the Dalmatian Islands the fall season brings decline in winter and spring precipitation. In the northern Adriatic, the reduction in precipitation is evident in all seasons. In the northeastern Mediterranean Region (or Adriatic-Ionian region, which encompasses Croatia), heat wave events have become more frequent, longer lasting, and more severe. The country experiences a largely Mediterranean climate with hot, dry, and sunny weather during the summer and relatively mild yet rainy weather during the winter in the coastal area. In the mainland, a typical continental climate can be experienced with four distinguished seasons; warm summers and cold winters and more precipitation in spring and late autumn/early winter. However, due to climate change, usual climate patterns are changing towards more unpredictable seasons.

Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Republic of Croatia



Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2022; Republic of Croatia

Observed Annual Precipitation 1901-2020; Republic of Croatia

Hydrology

Croatia contains large quantities of both surface water and groundwater resources, although they are unevenly distributed. The low-lying parts of the Danube Basin are dominated by arable areas, while the upland regions of northern and central Croatia are forested. The Basin is particularly unevenly populated. The majority live in the larger towns (density is greatest in Zagreb and Osijek), while other areas, particularly mountainous ones, are very sparsely populated.

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A major proportion of electricity generation comes from hydropower, with the Drava currently providing the largest capability. The most effective locations are already exploited; new sites could potentially cause significant environmental impacts. The Drava and the Danube are major routes for international transportation (80 % of goods shipped on inland waterways involve international trade) and the four-country Framework Agreement on the Sava Basin aims to further develop navigation. Discharging wastewater (both treated and untreated) into watercourses is common practice, but discharge directly into groundwater is prohibited. The majority of industrial facilities discharge into public sewerage systems; some of this discharge is then treated before release into watercourses. With regard to drinking water, 90 % of abstractions are from groundwater, with the remainder from rivers and reservoirs; there are few surface water intakes. An important measure for protecting drinking water aquifers is the adoption and enforcement of sanitary protection zones, a challenging task at most abstraction sites. Estimates indicate that 15 % of the mainland is at risk of flooding; however, the major part is protected to varying degrees. In the Sava Basin, due to the reduction in peak flows of flood waves in lowland flood storages, the middle basin plays a key role in protecting the Slavonian stretch and neighboring countries. Measures based on lowland flood storages and expansion areas have enabled the preservation of environmentally favourable conditions on wide floodplains. In the Drava and Danube Basins, protection is based on embankments and wide foreshores.

Water quantity

Croatia is endowed with relatively abundant water resources and is characterized by major rivers and the karst coastal area. Water resources differ in size and distribution in time and space. Water management includes a number of activities and measures aimed at maintaining, improving and ensuring the unity of the water regime in a specific area. The water regime is underpinned by essential water management principles and plans. With a national territory of 87,609 km^2, Croatia is at the meeting point of the Pannonian Plain, the Balkans and the Adriatic. The country straddles the border of two major catchment areas: the Danube Basin and the Adriatic Sea. Draining over 62 % of Croatia's mainland, the Danube Basin covers the northern and central inland section of the country and is home to 69 % of the population. Croatian territory accounts for 4.4 % of the entire Danube Basin. The Croatian section is dominated by major rivers (and their tributaries), notably the Drava, the Sava and the Danube itself. Croatia has been a signatory to the Danube River Protection Convention since 1994.

Water quality

Water quality, ecosystems and human health Croatia's major environmental problems are: air pollution (from metallurgical plants) and the resulting acid rain, which damages forests; coastal pollution from industrial and domestic waste; landmine removal and reconstruction of infrastructure consequent to 1992-95 civil strife. With regard to organic load, of the 28 % of wastewater that is treated, 43 % undergoes preliminary/primary treatment and 57 % secondary treatment. The most serious problems occur in small settlements (up to 2,000 inhabitants), where 40 % of the population live.

The situation in settlements with more than 10,000 inhabitants is considered satisfactory in the main. Around 44 % of all settlements with built sewerage systems have wastewater treatment plants. Of 109 plants, 38 involve preliminary treatment, 24 primary, 46 secondary and one tertiary. Changing economic conditions have meant many industries have constructed their own plants for preliminary treatment. At the same time, connection rates for public sewerage systems with central municipal plants have not increased at the rate predicted. Major parts of many settlements remain without connection to central treatment plants. With regard to agricultural pollution, and on the basis of processed data, the highest loads from diffuse sources are present in the Drava and Danube Basins and in the immediate Sava Basin.

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Bosnia and Herzegovina

Bosnia and Herzegovina is located in the Western Balkans of Central Europe. The country has a total surface area of 51,209 km^2, which is comprised of 51,197 km² of land and 12.2 km² of sea. Bosnia and Herzegovina shares borders with Croatia (931 km), Serbia (375 km), and Montenegro (249 km) and a coastline along the Adriatic Sea (25.5 km). Its location on the Balkan Peninsula places it within the Adriatic and Black Sea basins. The country's topography is largely hilly to mountainous with an average altitude of 500 meters (m) and a maximum altitude of 2,400 m. The country's land area is made up of 5 % lowlands, 24 % hills, 42 % mountains, and 29 % karstic regions (soluble rocks such as limestone, dolomite, and gypsum, characterized by underground drainage and sinkholes). Bosnia and Herzegovina also has a large network of transboundary rivers, including tributaries of Drina, Neretva, Una, Korana, and Glina, and rivers on its territorial borders such as the Sava, Una, and Drina. Bosnia and Herzegovina has a population of 3.3 million people (2020). Bosnia and Herzegovina submitted its Nationally-Determined Contribution (NDC) to the UNFCCC in 2016 in support of its commitment to the Paris Agreement and submitted its Updated NDC in April 2021. Bosnia and Herzegovina also submitted its Third National Communication (NC3) and Second Biennial Update Report on Green House Gas (GHG) Emissions in 2016. Identified adaptation priorities focus on agriculture, hydrology and water resources, energy, transportation, health, forests and biodiversity, and tourism. Adaptation plans in Bosnia and Herzegovina center primarily on coping with drought and flooding. Measures under consideration include modifications in crop rotation patterns, the application of new technologies to improve soils, the installation of windbreaks, and the establishment of a drought early warning system.

The geographical location of Bosnia and Herzegovina

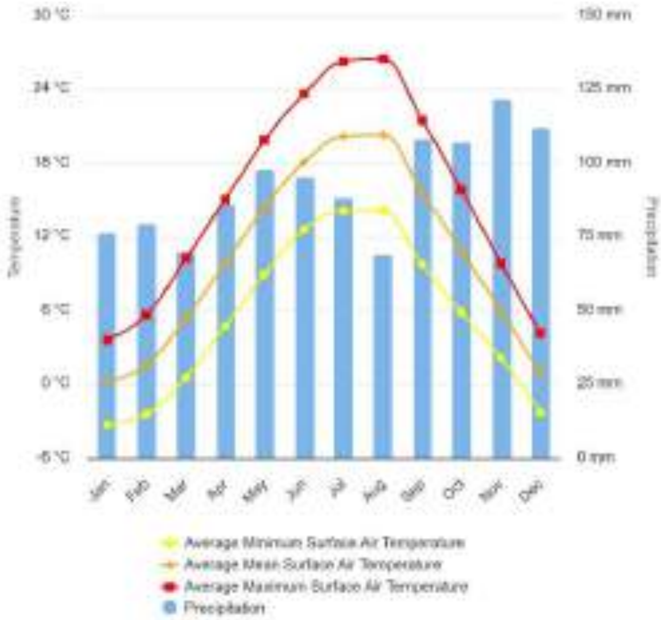
Climate

There are the following types of climate: temperate continental in the northern and central regions, colder climates for the sub-mountainous and mountainous, and an Adriatic climate and modified Adriatic climate along its coast. The country's climate varies from a temperate continental climate in the northern Pannonian lowlands along the Sava River and in the foothill zone to an alpine climate in the mountain region, and a Mediterranean climate in the coastal and lowland area of the Herzegovina region in the south and southeast. These climate characteristics are influenced by the Adriatic Sea as well as local topography, particularly the Dinarides Mountains, which are located along the coast and run from the northwest to the southeast parallel to the coast.

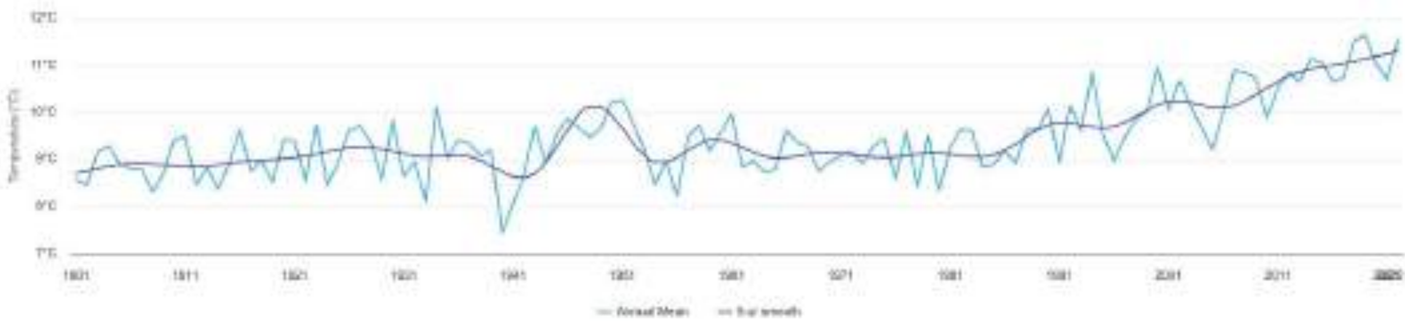
Bosnia and Herzegovina receives a relatively large amount of sun in its southern region as compared to its northern zones. The country also has a particularly rich biodiversity (one of the largest in Europe). This is due in part to the three distinct geological and climatic regions: the Mediterranean region, the Euro Siberian-Bore American region, and the mountainous Alpine-Nordic region. Historically, temperatures during the winter months (November to February) range from -6.0°C to 6.2°C and during the summer (May to September) from 9.8°C to 24.7°C.

Rainfall is largely constant throughout the year, however the seasonal onset and distribution of rainfall over the past two decades has reportedly been disrupted, causing unexpected flooding and periods of drought, along with high temperatures.

Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Bosnia and Herzegovina



Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Bosnia and Herzegovina



Observed Annual Average Mean Surface Air Temperature 1901-2022; Bosnia and Herzegovina

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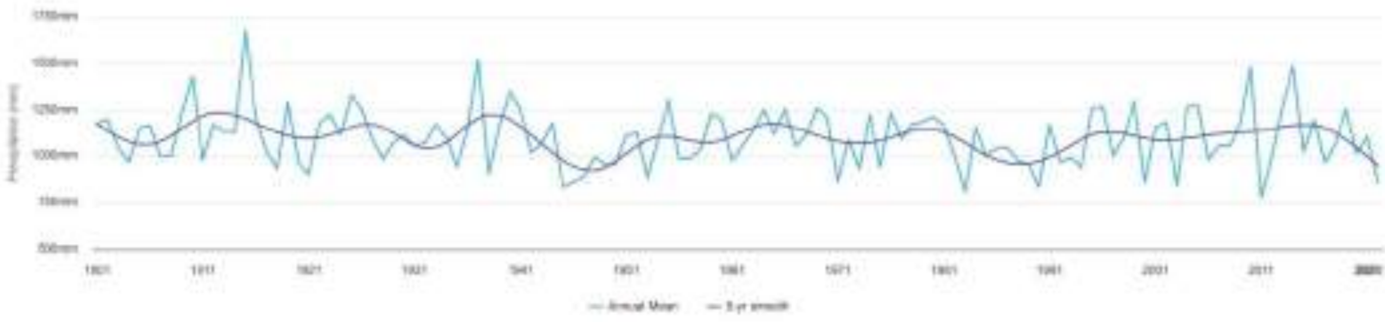

Observed Annual Precipitation 1901-2022; Bosnia and Herzegovina

Hidrology

The biggest cities in the Federation of Bosnia and Herzegovina account for 61 % of total water consumption. Sarajevo consumes 36 %, Mostar 10 %, Tuzla 9 %, and Zenica 6 %. Water consumption by industry is very significant. Part of the industrial water demand is met by drinking water from the water utilities, but the biggest industrial consumers typically also have their own water supply sources. Today, industrial technologies are working towards reducing consumption of all resources used during production and introducing water recycling wherever possible, as they are obliged to pay fees for water abstraction and wastewater discharge. The total water used by industry from its own water sources amounts to 5,914,770 x 10^3 m^3, a mere 17 % of pre-war consumption. Agricultural land covers 11,367 km^2 (43.5 %), of which 7,184 km^2 is arable. It is estimated that the total area in need of irrigation represents 808 km^2 (11.2 %) of total arable land, but present estimates suggest that only 16 km^2 (0.2 %) of arable land is irrigated in reality.
In the Republika Srpska (RS), the five biggest cities account for 50 % of total water consumption; Banja Luka (25 %), Bijeljina (10 %), Prijedor (7 %), Doboj (4 %) and Zvornik (4 %). Small amount of the industrial water demand (18 million m^3) is covered by drinking water from water utilities, while most is derived from insdustry's own sources (150 million m^3/year). Small quantities of water are used for irrigation. In Bosnia and Herzegovina, there is a large system of hydro-energy utilization named HET (Hydro power plants on the Trebišnjica river).
There are four hydropower plants, three in Bosnia and Herzegovina and one in Croatia, which have a capacity of 820 MW, and there are plans for new hydropower plants with the aim of gaining an additional 200 MW.

Water quantity

Waters in Bosnia and Herzegovina hydrographically belong to the Black Sea Basin (39,000 km^2, or 75.7 % of the country's total surface area) and to the Adriatic Sea Basin (12,000 km^2, or 24.3 %), although the precise lines of separation between these two basins have not yet been determined in certain areas because of the hydrologically complex nature of the karst. The Sava river is a recipient of water streams from the northern part of Bosnia and Herzegovina, which belong to the Black Sea basin, while the Neretva river is the only direct tributary of the Adriatic basin. The river basins of the Black and Adriatic seas supply Bosnia and Herzegovina with most of its fresh water. The country receives some 1,000 mm of precipitation annually. There are about 30 water reservoirs in Bosnia and Herzegovina, primarily in the Neretva and Trebisnjica basin and the Drin. Most are designed for hydropower and all are important for flood control, drinking water and irrigation. 90 % of drinking water comes from groundwater resources.

Water quality

Criteria prescribed by the Decision were used to assess the ecological status of water bodies.Based on the criteria from the Decision and the results of the 2021 examinations, the ecological status was assessed for 59 water bodies, where 1 water body is in a high status, 35 water bodies are in good status, 14 water bodies are in moderate status, 6 water bodies are in poor status, and 3 water bodies are in bad ecological status. Parameters that are most commonly outside the boundaries for good status are physico-chemical parameters of ecological status (HPK - permanganate, BPK_5, TOC, ammonia nitrogen, orthophosphate, total phosphorus, nitrate nitrogen, and total nitrogen) and specific pollutants such as zinc, copper, and chromium. According to the data on hydromorphological changes, out of 59 water bodies, 16 have a high status, 26 water bodies are in good status, 12 are in moderate status, and 5 are in poor status. According to the Law on Hydrological and Meteorological Activities of the Republic of Srpska (Official Gazette of the Republic of Srpska, No. 20/2000), the Republic Hydro-meteorological Institute conducts water quality monitoring and ensures the connection of the Republic of Srpska with international telecommunication and information systems in the relevant field and exchanges data and processed information in accordance with international obligations. Due to a lack of capacity, the Republic Hydro-meteorological Institute is currently unable to carry out activities in the field of water monitoring. According to the Law on Waters (Official Gazette of the Republic of Srpska, No. 50/06), monitoring of water quality in the Republic of Srpska is conducted by the Public Institution "Vode Srpske". Additional information can be found on the website of the Public Institution "Vode Srpske".

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Republic of North Macedonia

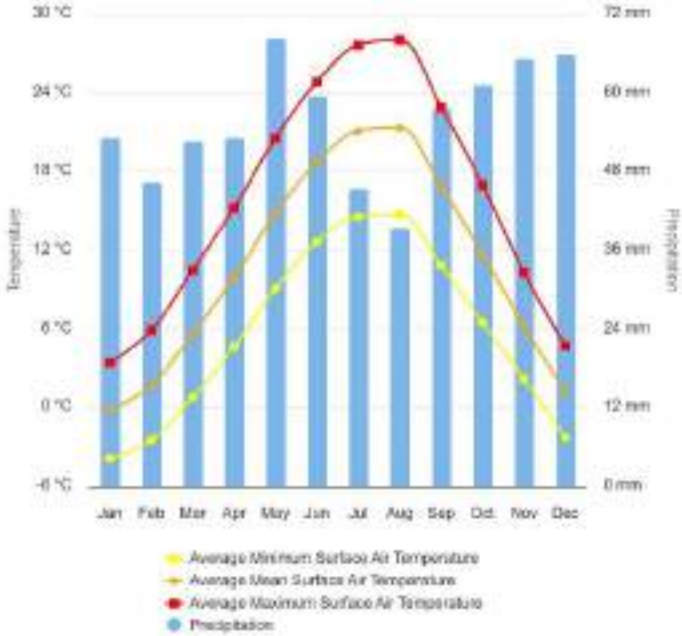
The Republic of North Macedonia is a small (25,713 km^2), landlocked country that is located in the middle of the Balkan Peninsula in Southern Europe. It has a diverse topography with high mountains and deep valleys surrounded by mountains, picturesque rivers, large and small natural lakes, and spas. Land use for agriculture covers almost 50 % of the surface area of the country, and forests cover approximately one-third of the country. As an upper middle-income country, foreign trade accounts for more than 90 % of its GDP. The agriculture sector also contributes to the country's GDP and provides employment to 21.7 % of the workforce. The country's population is approximately 2.1 million (2020) people. The Republic of North Macedonia is vulnerable to the impacts of climate change from changes in climatic conditions, such as increases in temperature and decrease in precipitation and increases in extreme weather events, such as heat waves. These pose increasing risks to the country's agricultural sector, which contributes to its overall economy.

The geographical location of Republic of North Macedonia

Climate

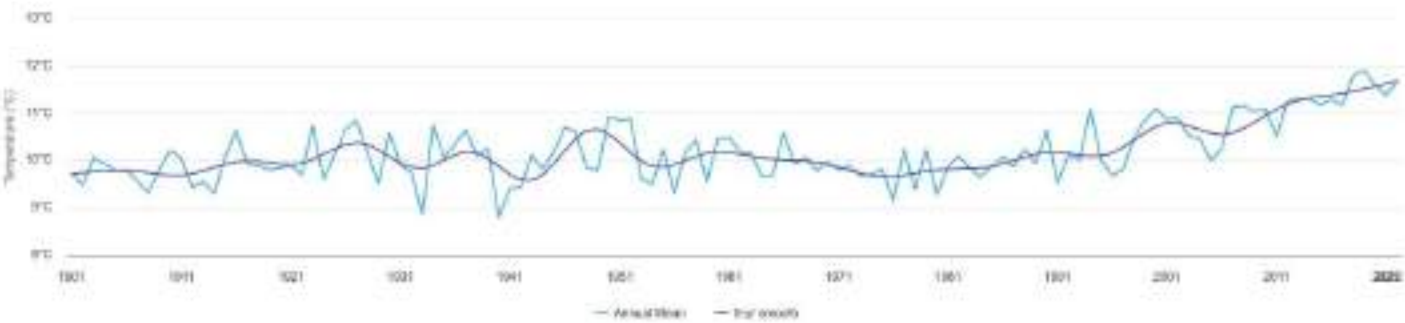
Despite the relatively small area of the Republic of North Macedonia, the country has a diverse climate, with eight climatic regions. Annual mean temperatures in Republic of North Macedonia range from approximately 8°C in the north-west regions to 15°C in central regions.

The coldest month is January, and on average, July is the hottest month. Precipitation generally increases from east to west across the country, with annual precipitation ranging from about 400 mm in the south-eastern and central regions to over 1,000 mm in the mountain areas in the western and northwestern regions. In the southern regions with a Mediterranean climate, the months of October, November, and December have the highest precipitation, while in the central and norther regions, where the climate is more continental, the greatest amounts of rainfall occur in May and June.

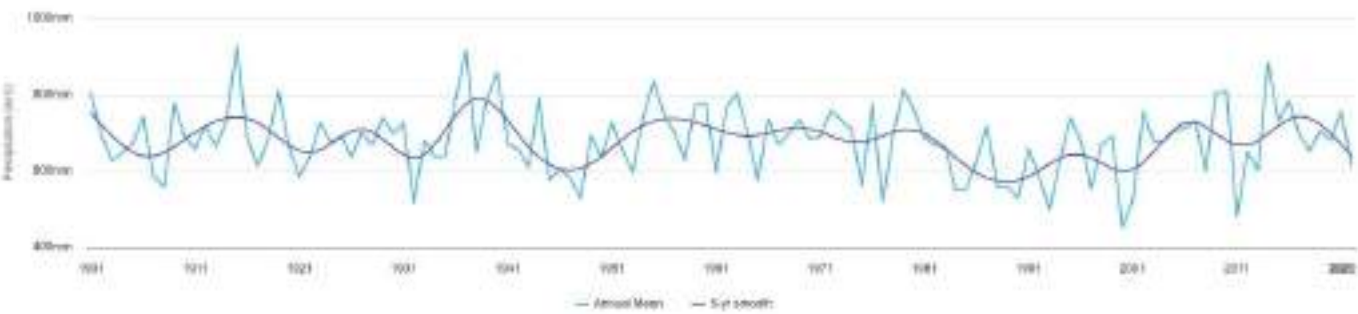


Observed Climatology of Average Mean Surface Air Temperature 1991-2020; North Macedonia

Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; North Macedonia



Observed Annual Average Mean Surface Air Temperature 1901-2022; North Macedonia



Observed Climatology of Precipitation 1991-2022; North Macedonia

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Hidrology and water quantity

The total water resources of Macedonia are estimated at: 18.8 x 10^9 m^3 from rainfall (with a 733 mm average rainfall); 6.36 x 10^9 m^3 discharged from the river basin areas; 0.52 x 10^9 m^3 groundwater; and 0.42 x 10^9 m^3 from the largest springs. According to the World Resources Institute, the annual water resources per capita for the Republic of Macedonia are about 3.137 m^3/year, while the average value for Europe is 10,680 m^3/year. Irrigation is the major user of the total water demand in the country, about 40 %. According to the 2002 census, the number of households connected to public systems for water supply in urban areas is 82 % to 100 %. In rural areas, this percentage varies between 10 and 100. For urban water supply, both surface and groundwater are used, as well as a combination of the two sources.

The variations in the hydrological cycles of the rivers in the country are determined by the seasonality of the precipitation and the temperature. The assessed rate of reduction of the effective rain for 2050 is around 15 % for the regions under the prevailing mountainous-Alpine climate impacts (represented by the stations at Lazaropole, Popova Sapka, and Solunska Glava), around 20 % to 23 % for the south-western part of Macedonia under the continental climate impacts (represented by the stations at Ohrid and Resen), and around 35 % to 40% for other regions of Macedonia. The estimated rate of reduction of the effective rain for 2100 is around 30 % for the regions under the prevailing mountainous-Alpine climate impacts, around 45 % for the south-western part of Macedonia under the continental climate impacts, and around 70 % for other regions of Macedonia. Taking into consideration the reduction of effective rain and the fact that 84 % of the available water quantities are formed on the territory of the country, it is obvious that this high rate of reduction of effective rain is going to cause a drastic reduction of the available water quantities until the end of this century.

In order to estimate the impacts of climate change on hydrological resources in the Republic of Macedonia, an assessment of climate change's impact on water quantity and quality should be made. Analysis of the water resources quantity has been carried out for twelve hydrological stations in the three watersheds (catchment areas) and for the surface water level of the three natural lakes. The methodology used for sensitivity analysis of the water resources includes the analysis of the variability of the historical time series and the trend lines, homogeneity and confidence analysis of the respective time-series elements, and the creation of a correlation graph of the time series. Since every projection of the future hydrological variables based on historical data requires that conclusions be drawn from datasets without considerable non-homogeneity, only data of homogenous time series have been used for the presentation of variations and trend lines of the annual discharge values.

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Republic of Moldova

The Republic of Moldova, covering an area of 33,846 km^2, is a land-locked country located in Central Europe in the northwestern Balkans. The geographic relief of Moldova is represented by hills and flatland areas, with uplands mostly in the central part of the country. Moldova is a small, lower-middle-income economy with a population of about 2.6 million (2020), a decrease of 0.6 % since 2000. The majority of the population is concentrated in the rural areas. Its main sectors of economy are agriculture, manufacturing or industry, and the services sector, including transport and communications, financial, and construction sub-sectors. Moldova is vulnerable to the impacts of temperature increase, changes in precipitation regimes, and increases in climate aridity from extreme weather events such as heatwaves and frost, floods, storms with heavy rains and hails, and severe droughts. Floods are a major concern to Moldova as 10 major floods have been reported over the past 70 years, three of which occurred in the 21st century (in 2006, 2008, and 2010).

The geographical location of Republic of Moldova

Climate

The climate of Moldova is moderately continental, characterized by relatively mild winters with little snow, long warm summers, and low humidity. The average annual temperatures vary between 6.3°C in the North to 12.3°C in the South. Warm weather lasts about 190 days. The average annual precipitation varies between 307 mm – 960 mm per year. The majority of precipitation occurs in the form of rainfall, and snow accounts for as little as 10 %.

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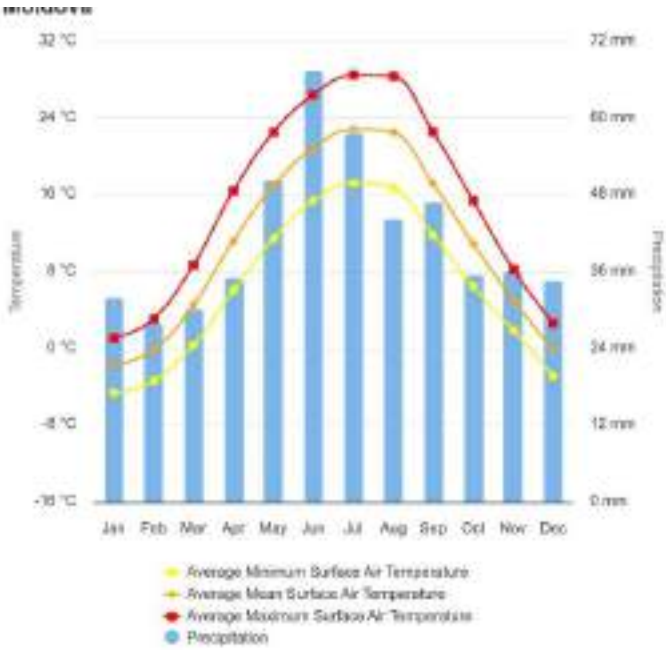
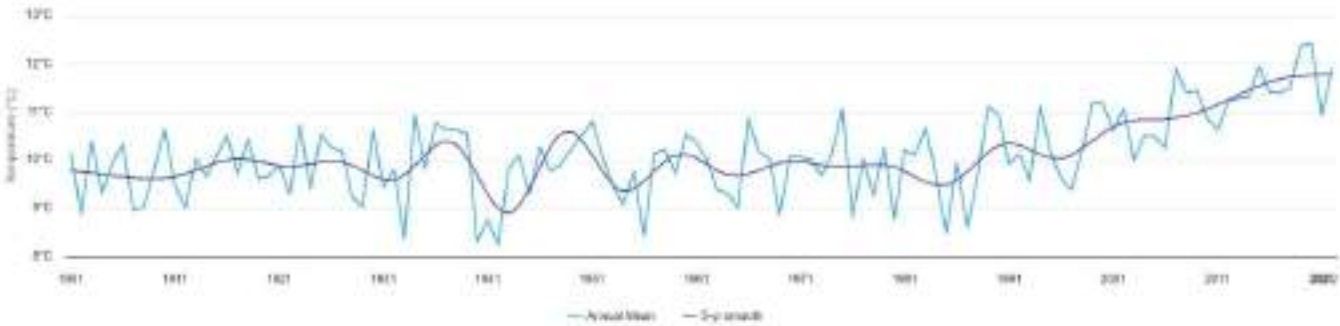
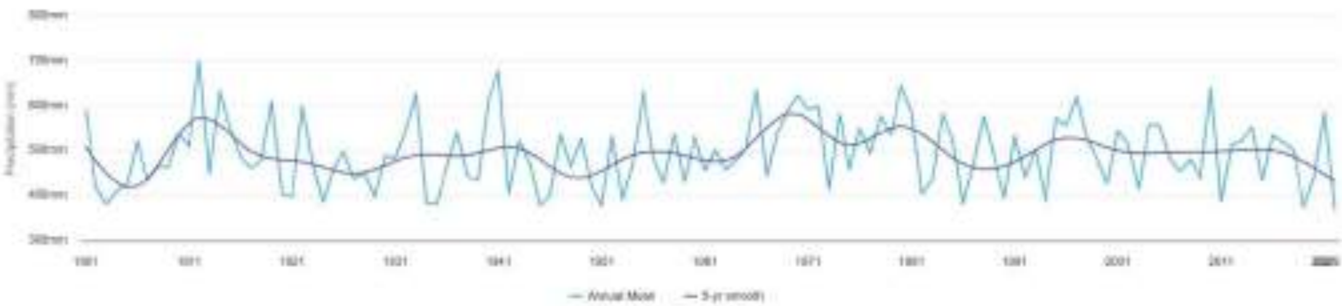


Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Republic of Moldova

Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Republic of Moldova



Observed Annual Average Mean Surface Air Temperature 1901-2022; Republic of Moldova



Observed Climatology of Precipitation 1991-2022; Republic of Moldova

Hidrology and water quantity

The total available water resources in the country amount to 5.6 km^3, including 4.3 km^3 of surface water and 1.3 km^3 of groundwater. The main groundwater reserves are located in deep confined aquifers, whose natural recharge capacity is limited. Irrigation has been considered a valuable measure to mitigate drought risk, increasing yield by 25–50 % in normal years while avoiding losses in drought years. Irrigated land has diminished drastically compared to the Soviet period due to the aging and deterioration of the equipment, the rising cost of energy for the pumps, the farm restructuring process – older pumping systems not adapted to the new size of plots – and the overall collapse of the agriculture sector since the 1990s. Water resources for agriculture are scarce, and irrigation infrastructure is almost nonexistent among small-scale farmers (high costs especially). Due to the uncontrolled use of water from wells and short boreholes for irrigation in households and small farms, the water table depth in these aquifers has dramatically increased, leading to the depletion of aquifers in many regions of the country.

Water quality

Even though water resource quality has improved since 1990, some of the inner rivers, especially in the southern region, have high salt content, making waters unsuitable for direct use. Moreover, water quality in wells does not comply with the national standard for drinking water due to excessive water hardness and concentration of nitrates. Approximately 12% of the total population has no access to potable water, which is primarily polluted by nutrient runoff from farm fields, storage and use of manure, agrochemicals, and waste. Projections on climate change impacts on water resources show that the two major basins of the country, Nistru and Prut, will experience 15.9 %, 36 %, and 57.7 % decline in available surface water resources by 2020, 2050, and 2080, respectively.

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Montenegro

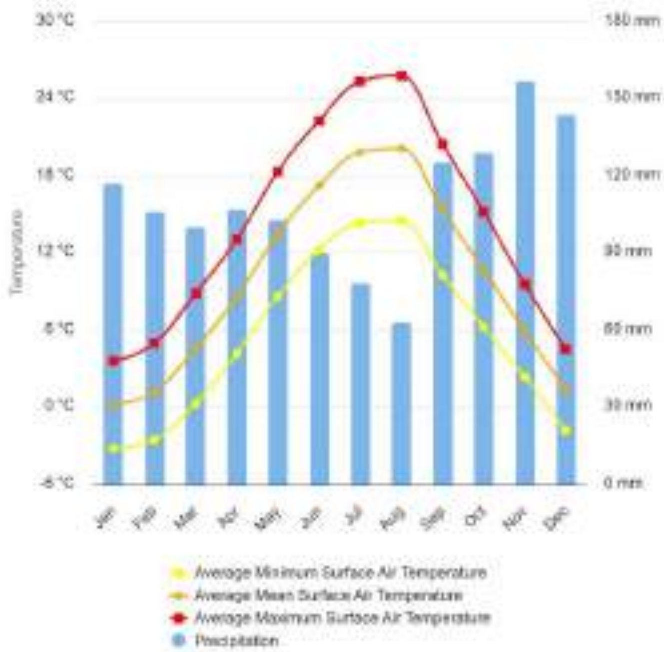
Montenegro is a young, small state in the Western Balkans, located in the central part of a moderately warm zone in the Northern Hemisphere (41°52' and 43°32' latitude North and 18°26' and 19°22' longitude East). It borders Croatia in the west, Bosnia and Herzegovina in the west/northwest, Serbia and Kosovo in the north and northeast, and Albania in the east/southeast. Its Adriatic Sea coastline is 293 km long. According to 2013 data, the country has a population of 624,000, of which 63.23% lives in urban zones and 36.77 % in rural ones, GDP per capita is estimated at 5,356 EUR. Owing to its proximity to the Adriatic and Mediterranean Seas, it has a Mediterranean climate with warm and somewhat dry summers and mild and rather humid winters. Climate monitoring and assessments show that the Montenegrin climate has changed as a result of global climate change as well as variability (Second National Communication). Recent studies indicate that Balkan countries are particularly sensitive to climate and precipitation change, with weather-related events becoming more frequent and intense. Montenegro has ratified and begun to implement all international conventions and protocols on climate change. Substantial further implementation efforts remain, including those required by the EU climate acquis. The Government of Montenegro integrated climate change into its National Strategy on Sustainable Development, including urban plans and National Communications on Climate Change.

The geographical location of Montenegro

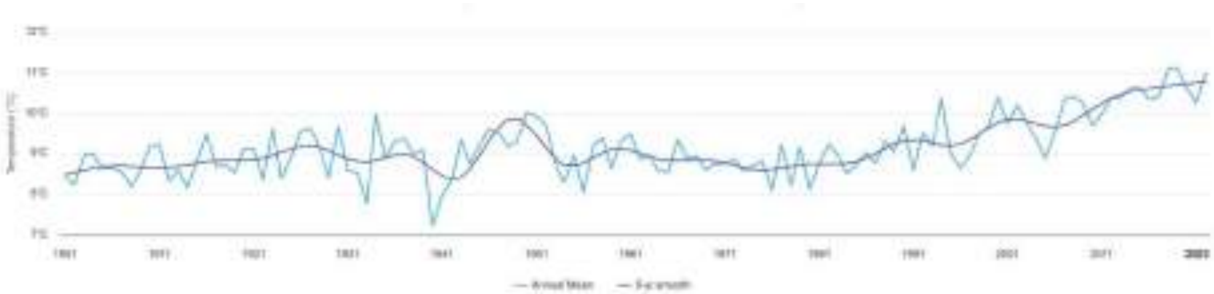
Climate

Historical climate information plays a significant role in facilitating the contextualization and interpretation of future climate projections. Climate variables (temperature and precipitation) can be analyzed at various levels in terms of trends, seasonality, and spatial variability. In fact, temperature and precipitation exhibit substantial differences from month to month and from one location to another even within the same country, region, or watershed. The global level gridded climate data for the period of 1901-2016 is provided by the Climatic Research Unit (CRU) of the University of East Anglia (UEA), and reprocessed by the National Center for Atmospheric Research (NCAR) of the University Corporation for Atmospheric Research (UCAR). A Glossary, Metadata, and a Guide to Read Climate Data Visualizations are provided to facilitate the use of the Climate Change Knowledge Portal (CCKP).

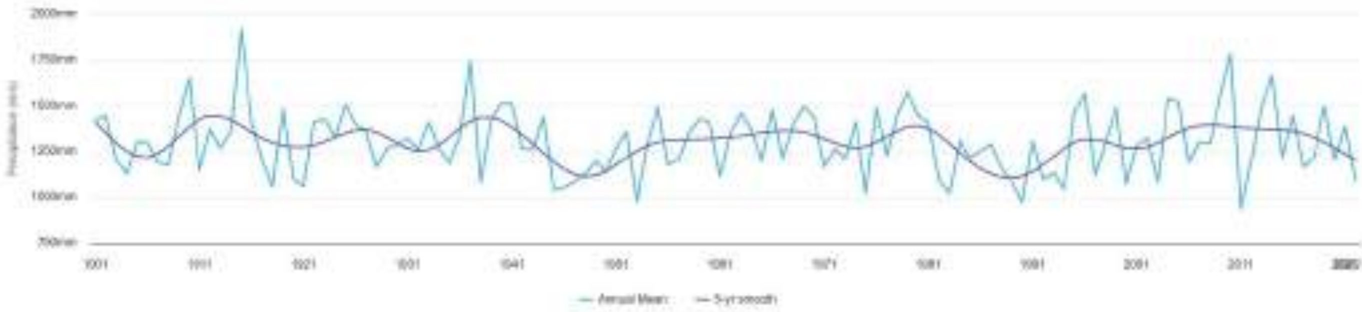
Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Montenegro



Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Montenegro



Observed Annual Average Mean Surface Air Temperature 1901-2022; Montenegro



Observed Climatology of Precipitation 1991-2022; Montenegro

Hidrology

The Republic of Montenegro has a Mediterranean climate with hot, dry summers and autumns and relatively cold winters with heavy snowfalls inland. The terrain is a highly indented coastline with a narrow coastal plain backed by rugged high limestone mountains and plateaus. Montenegro's surface, which totals 13,812 km^2, is drained into two catchment areas: the Adriatic and the Black Sea. The total area of the Black Sea catchment area is 7,545 km^2 (54.6 % of the territory). This part is drained by the River Ibar, the Zapadna Morava, the rivers Tara, Piva, Lim, and Cehotina, and the Drina. The Montenegro part of the Adriatic catchment area is around 6,560 km^2 (45.4 % of the territory). The biggest water courses are the Zeta and the Moraca, or the Moraca after their confluence in Podgorica, and the Bojana. Also, the Sutorina, Drenovštica, Lukavac, Građevica, Bečićka and Reževića rivers, Željeznica, Rikavac, Bratica, Brdela, and Međureč empty directly into the Adriatic sea. Lake Skadar is the largest in the Balkans and, by the volume of retained water, the second after Lake Ohrid. The complex of Lake Skadar, Drim, and Bojana has extremely complicated hydrogeography, with a catchment area of around 20,000 km^2. It is formed in the territories of Serbia, Macedonia, Greece, Albania, and Montenegro, and there are a large number of hydroelectric power stations. With an average outflow of 40 $l/sec/km^2$ (or 19.5 km^3/year), Montenegro ranks among the top four % of countries with the highest average outflow. Given that at least 95.3 % of Montenegro's waterways originate in its territory, it is safe to say that water is the country's greatest natural resource. In fact, Montenegro is one of the wealthiest countries in Europe in terms of water. However, although the country records high levels of precipitation, a large part of its territory (Orijen, Lovćen, Rumija and Katunska Nahija) does not have enough water because it is lost in the underground karst.

Water quantity

In 2005, the total volume of water delivered was 53,671,000 m^3; 33,460,000 m^3 to households, 13,165,000 m^3 to businesses and 7,046,000 m^3 to other consumers. Total losses were 48,195.000 m^3. Despite the apparent abundance of water, around 35 % of Montenegrin territory suffers from a chronic lack of water, which can only be solved by means of expensive hydraulic procedures. Around 10 % of the territory has a problem with seasonal surplus water. The problem is caused by an inadequate infrastructure in terms of water supply.

As a consequence of climatic conditions, the uncontrolled use of water, huge losses in the water supply system and inadequate infrastructure, water consumption is double that in western Europe. Moreover, there is insufficient provision for drinking water in the coastal region during the tourist season.

Water quality

The quality of most Montenegrin surface waters is generally adequate during most of the year, but there are exceptions and hotspots. Water quality monitoring of the rivers, lakes, and coastal waters reveals the negative impact of industrial and municipal waste-water discharges. The most polluted are two small rivers in the vicinity of Pljevla in northern Montenegro – the Vezisnica and the Cehotina. The stretch of the River Ibar also exceeds standards for BOD, ammonia, phosphates, nitrates, phenols, detergents, mineral oils, manganese, mercury, and pathogens. The water quality of Skadarsko Jezero meets all water quality standards for its category, with the exception of ammonia and the resultant eutrophication is documented in the northwest part of the lake. Around 65–70 % of the population is provided with water through a water supply system in city centers and larger towns, while around 30 % in villages use alternative sources. The population of Montenegro is supplied with water from groundwater sources. The measures implemented for the sanitary protection of water sources used to supply the population comply with and exceed existing legal obligations. To date, legal investigations have not been carried out, and the protection zones for most water sources have not been determined. At present, the precise identification and mapping of all water sources and their zones of protection is not possible. Water consumption is twice the western European average as the result of climatic conditions, uncontrolled use of water and significant losses in the water supply system and there is insufficient protection of drinking water in the coastal region during the tourist season. This is of particular significance since most pollutants are found outside areas with developed collection systems and large-scale purifiers, which is why the implementation of adequate solutions for water treatment is vital for environmental protection. The percentage of the population with access to sanitation is relatively small and most of the coverage is in areas close to town centres. Approximately 35 % of the population in urban areas is not connected to sewers. This is due to the underdevelopment of the primary and, in particular, secondary system of wastewater. A large percentage of the population uses septic tanks and wells for the drainage of wastewater, and in towns where natural conditions allow, wastewater is discharged directly into watercourses. The status of water in Montenegro is determined by the Regulation on the Classification and Categorization of Surface and Groundwater, in which there have been established three different categories. A regulation on the classification and categorisation of surface and groundwater was passed so as to ensure that 'the marginal value of quality' was brought into line with the terms of Directive 98/83/EC on the quality of waters intended for human consumption and Directives 75/440/EEC and 79/86/EEC.

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Directive 75/440/EEC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy

Directive 79/86/EEC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy

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Albania

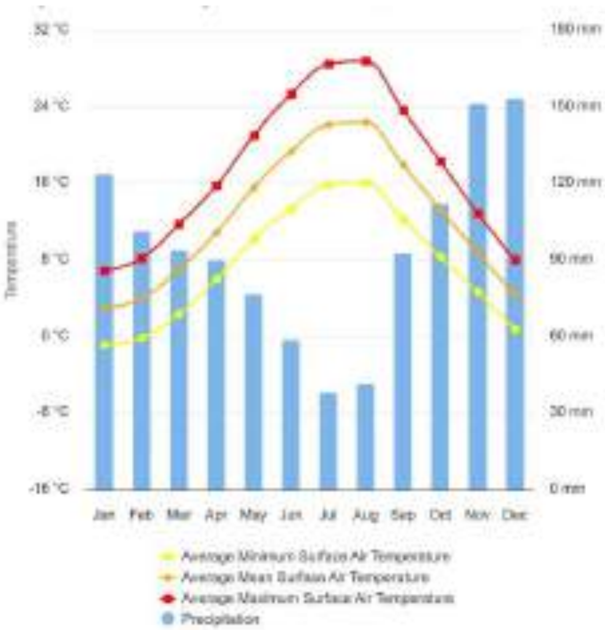
Albania is a small mountainous country on the western side of the Balkan Peninsula in Southeastern Europe, with a land area of 28,748 km^2. Albania shares borders with Montenegro to the northwest, Kosovo to the northeast, the Republic of North Macedonia to the east, and Greece to the south. The country has a long coastline along the Adriatic Sea, which forms the majority of its western border. 70 % of Albania's territory is mountainous, with an average altitude of 700 m above sea level. Albania enjoys a Mediterranean climate, with mild and humid winters followed by hot and dry summers. The country experiences rainfall primarily during the second half of the year, though climate conditions differ considerably between agroecological zones. The coastal plains experience a strong maritime influence, causing a gradient of lower temperatures and reduced precipitation eastwards from the coast. Strategic review and policy integration is currently led through the country's National Adaptation Planning, which started in 2015 and is expected to be adopted circa 2020. Albania's climate change action is also defined through its Third National Communication (NC3), which it published in 2016. Albania remains committed to developing a long-term, low-carbon development strategy as well as reducing its current greenhouse gas emissions.

The geographical location of Albania

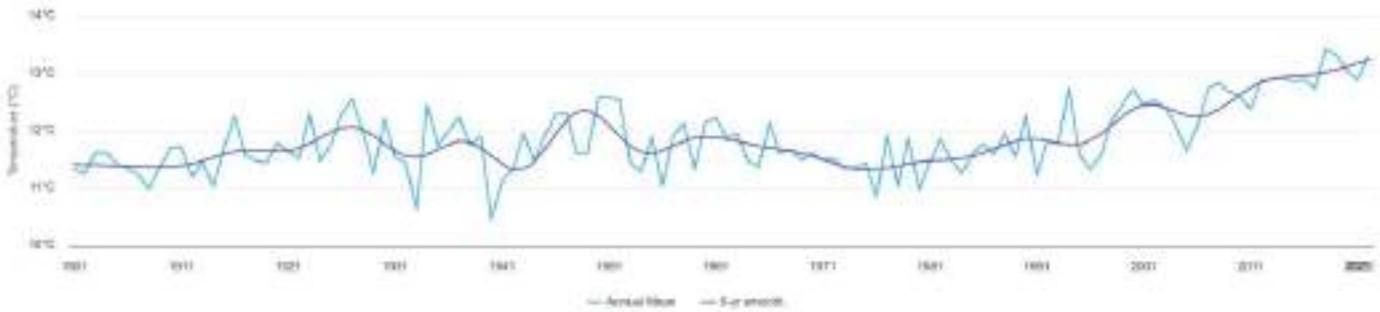
Climate

Albania has a subtropical Mediterranean climate. Its topography is dominated by its mountains, hills, and coastline, and the country's geologic and climatic characteristics result in an extensive network of rivers and lakes. As such, the country's mostly mountainous landscape is endowed with abundant water resources, diverse flora and fauna, and an extensive coastline on the Adriatic and Ionian Seas. Average annual temperatures vary from 17.6ºC (in Saranda to the South) to 7ºC (in Vermosh in the North). Lowland areas are characterized by a stable mean temperature of 14ºC–16ºC. Maximum temperatures can reach up to 11.3ºC in mountain areas and 21.8ºC in lowland and coastal zones. The northern, western, and southwest regions of Albania experience the highest amounts of rainfall. Annual average rainfall is 1,430 mm; however, the spatial and seasonal distribution varies, with the majority of rainfall occurring during the winter months. The most humid areas are the Albanian Alps in the north (Koder Shengjergj with 2,935 mm and Boga with 2,883 mm of annual precipitation) and Kurveleshi in the south (Nivica with 2,204 mm of annual precipitation). The highest amount of precipitation is experienced in November and the lowest amounts during July to August. Snowfall occurs in the Albanian Alps, in the central and southern areas. Average snowfall depth in mountainous areas is 600–1,200 cm, with the highest snowfall reaching 2–3 m depth in Vermosh, Boga, Theth, Valbona, Curraj and Lure. In the West Plains lowlands to the southwestern coast, snow is rare.

Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Albania



Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Albania



Observed Annual Average Mean Surface Air Temperature 1901-2022; Albania

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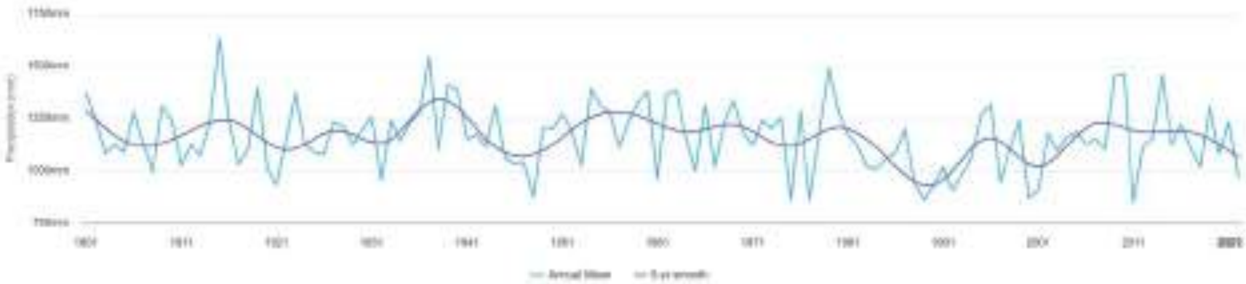
Observed Climatology of Precipitation 1991-2022; Albania



Observed Climatology of Precipitation 1991-2022; Albania

Hidrology

Due to the ease of extraction, groundwater has often been unnecessarily used in industry and for irrigation in agriculture. The latter has become a cause of concern, as 21% of groundwater extracted is used in inefficient irrigation practices. In some areas of Albania, there has been rapid depletion of groundwater resources; this disastrous trend is likely to continue in the next decade. It is often associated with increased salinity and alternated hydro-chemical balances in the aquifer, indicating brackish water intrusion. Population movement toward cities has put additional pressure on the water resources of some lowland areas, where extraction rates are increasing steadily. Surface water is widely used in irrigation, electricity production, industrial processes, mining, construction, etc. Water for irrigation is taken from rivers and from 626 reservoirs with an estimated total volume of 562 million m3, which is estimated to irrigate 1,540 km^2, which is 22 % of total agricultural land. Albania had a relatively good irrigation network some decades ago; however, the irrigation technology used was mainly open channel flow, which has resulted in massive wastage of water.

Water quantity

Water resources are considerable in Albania. River discharge into the sea is estimated to be around 40 km^3/year with an annual specific discharge of 29 L/sec/km^2, which is one of the highest in Europe. Groundwater resources represent about 23 % of the total renewable resources. Groundwater sources are the main source of drinking water and the major source for irrigation. Because of the geological structure of the Albanian mountains, with developed karst manifestation and highly permeable gravelly aquifers in the lowland areas, groundwater resources are abundant and of good quality. The hydrographic basin of Albania has a total area of 43,305 km^2, of which only 28,748 km^2, or 67 %, is within the Albanian borders. The overall renewable resources amount to 41.7 km^3 or 13,300 m^3 per capita, of which about 65 % is generated within Albania and the remainder in upstream countries. Resources are unevenly distributed throughout the country. The major water resource is surface water, which is found in rivers, lakes, and lagoons. The most important rivers are the Drini, Mati, Ishmi, Erzeni, Shkumbini, Semani, Vjosa and Bistrica. The country has several rivers (which form the six main basins), a number of natural lakes, and a multitude of artificial lakes for energy and irrigation. Lakes cover about four % of the country's territory. The largest lakes are Ohrid, Prespa, and Shkodra. There are also several reservoirs, totalling 5.60 km^3 of storage capacity, which have been built for flood protection, irrigation, and the production of hydropower.

Water quality

Albania's major environmental problems are deforestation, soil erosion, and water pollution from industrial and domestic effluents. It is important to stress that Albania has used massive amounts of fertilizers and pesticides in agriculture, especially before 1990. Because the detection of these pollutants is difficult and more advanced analytical capacities are needed, it could be the case that the scale of this kind of pollution has been underestimated. Water quality in the main rivers is as follows: Chemical analysis and quality monitoring have shown that the Drini river has good water quality with stable mineral composition and low metallic concentration. There should be no restrictions on using its water for irrigation or other purposes. Groundwater quality is generally satisfactory in the mountainous part of the basin. Lowland areas have some problems with saltwater intrusion, but this has not been sufficiently investigated. The Mati contains a high concentration of heavy metals, flowing through an important copper mining area. These pollutants should be at lower levels than previously due to diminished mining activities since 1991. At present, the effect on groundwater resources downstream and in coastal areas has not been assessed. Areas near Lezhe and Laç have high pH values and levels of chloride in groundwater, which indicates the presence of saltwater intrusion. This may be related to the excessive drawdown of the water table due to overexploitation. The rest of the basin has acceptable groundwater quality. The Erzeni and Ishmi rivers present high levels of iron, manganese, nitrates, BOD, etc. This is due to domestic and industrial discharge from densely populated areas along their beds. Groundwater quality near Fushe-Kruje and Tirana is generally acceptable; in some cases, excessive concentrations of iron, nitrite, nitrate, sulpfate, and hardness have been observed. Part of Tirana city is supplied with water through extraction from this good-yield aquifer. The Shkumbini river presents high levels of iron, nitrites, ammonia, etc. due to mining activities upstream. Another important source of pollution is the metallurgical industry in Elbasan, which is responsible for serious effects on biodiversity in the area. Information on the river's quality has not been updated, while the levels of discharge of pollutants into the water body have recently changed. Water extracted from the alluvial riverbanks is used – without any significant treatment except chlorination – for human consumption in the towns of Lushnja and Rrogozhina. Odor and sulfate problems are well known, especially around Lushnja. It should be noted, however, that data on water quality derive from standard chemical analysis of the most common pollutants, while analysis of hydrocarbons is often not included; pesticides and heavy metals are scarcely performed because of insufficient analytical capacities in the only two laboratories that specialize in this process. Water analysis of the Semani River shows a high content of oil, phenols, BOD, ammonia, etc. This pollution is caused by the oil extraction and refinery industry, as well as some domestic discharge of wastewater. Downstream, the negative effects on biodiversity, especially in the coastal area, are immense. The groundwater in this aquifer contains high levels of ammonia. It is not clear if these levels are caused by water infiltration from the polluted river, or from the mineral composition of the soil (this area is a former swamp). The water quality in the Vjosa river is generally good, with slightly high values for hardness and chlorides in some parts. Use of this water for different purposes should not be a problem. Groundwater resources are of good quality, with some presence of nitrite and nitrate around the Novosela area. The cities of Fier,

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Vlora, Gjirokastra and Saranda are supplied from this aquifer. Many springs are present in this basin; some of these are among the biggest in Albania. Significant industrial sources of pollution are not yet present.

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Luxembourg

Luxembourg is a territory of 2 586 km^2. The maximum distance from north to south is 82 km, and from west to east, about 57 km. Of the total area of Luxembourg, 85.5 % was agricultural land and land under forest – with around 51 % for agriculture and 35 % for forests. The built-up areas occupied 9.5% of the total surface, and land was covered by water and transport infrastructure about 5 %. The north of Luxembourg is a part of the Ardennes and is called "Ösling". Its altitude is at an average of 400 to 500 meters above sea level. The most important rivers are the Moselle, the Sure, the Our – all three delimiting the border with Germany – and the Alzette. At the end of 2020, the population of Luxembourg amounted to 625,000 inhabitants. Within slightly more than 55 years, the residential population has grown by some 276,000 inhabitants or about 87.5 % – 55.7 % since 1990. Two particular threats from climate change are of concern for Luxembourg: those relating to forests and temperature extremes and summer precipitation reduction are also causes of concern due to their impacts on human health, especially of the most fragile persons and the elderly (heat, air quality), and impacts on water quality in summer when rivers flow are usually at their lowest.

The geographical location of Luxembourg

Climate

Two particular threats from climate change are of concern for Luxembourg: those relating to forests and temperature extremes and summer precipitation reduction are also causes of concern due to their impacts of human health, especially of the most fragile persons and the elderly (heat, air quality), and impacts on water quality in summer when rivers flows are usually at their lowest.

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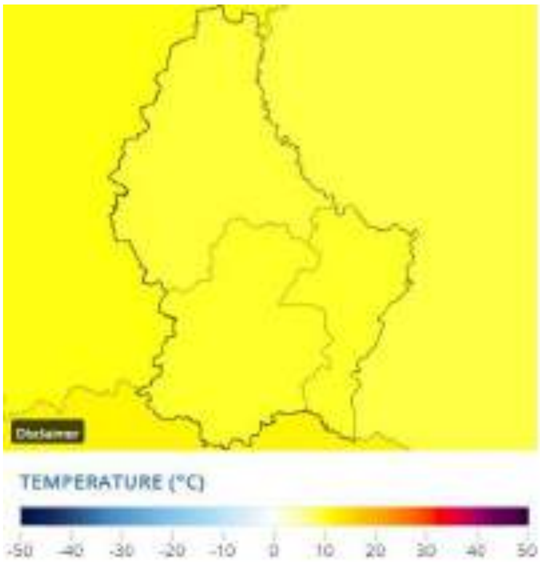

Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Luxembourg

Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Luxembourg

Observed Annual Prcipitation 1991-2020; Luxembourg

Hidrology and water quantity

The usage intensity of available resources in households, industry, and agriculture is relatively low compared to other developed countries, reflecting the low level of abstraction for agriculture. Daily household consumption is 140 liters per capita. There is little loss through leakage, and many of the water supply systems have been upgraded over the last 10 years. Water withdrawal in the country has been estimated at a total of 69.2 million m³. This water abstraction can be itemized by user sector. It was estimated that 47 million m³ was dedicated to urban use in 2009 (around 67 % of total water consumption). In 1999, water withdrawal for agriculture was estimated at only 0.2 million m³; and for industrial use, 22 million m³ (which represents around 32 % of the total abstraction). Groundwater provides 57 % of the 47 million m³ of drinking water used annually in Luxembourg. Also, in the southern industrial region, industries and utilities must draw from the water table of the Luxembourg sandstone aquifer, located in the center of the country, and from the Esch-sur-Sûre reservoir in the north to cover their water needs. Under the legislation of Luxembourg regarding water (The Water Act), there must be a balance between depletion and renewal of underground water sources so that they will be in good condition by no later than 2015. The preference given to surface tapping over groundwater pumping eliminates the risk of over-exploitation of the sandstone aquifer, which supplies more than half of the country's drinking water. On the other hand, the Esch-sur-Sûre reservoir, which provides 43 % of the water supply to public utilities in Luxembourg, is in a critical state of eutrophication. While the demand for water from industry has decreased with the improvement of industrial processes, notably in the metallurgy sector, household consumption has increased by 1.35 % per year over the last 15 years, reflecting the country's strong demographic growth and the steady increase in cross-border workers.

Water quality

It is estimated that only 30 % of surface water bodies will comply with the EU's 2015 targets for chemical and biological quality as determined under the EU Water Framework Directive (WFD) (Directive 2000/60/EC). The continuous significant demographic growth that Luxembourg has experienced these last 25 years - and that will most likely continue in future - is the main threat to water resources and water quality. With regard to drinking water, sources have not yet been protected despite a legal obligation to do so dating back more than 15 years. Moreover, rural development policies have focused more on farm modernization and the continued use of agricultural land than on the targeted protection of water resources. According to the Water Act, all surface water bodies must be protected, improved or restored to meet the definition of "good status" by the end of 2015. However, it is estimated that at least 72 % of surface water bodies (watercourses and reservoirs) will not meet the 2015 chemical and biological quality targets under the WFD. While the pollution level in watercourses has decreased slightly in recent years, 39 % of watercourses are still heavily polluted and 54 % are moderately polluted. With regard to new contaminants, the watercourses of the Alzette and the Mess, located in industrialized and heavily populated environments, have been found to contain xenobiotic pollution from antibiotics, analgesics and hormones. There are several xenobiotic pollutants coming from diffuse pollution that are found in all major watercourses. These pollutants can not be eliminated by the existing purification plants. The quality of all drinking water resources (250 catchment sources, 50 drilling holes and the Eschsur-Sûre reservoir) is regularly monitored. Suppliers are responsible for monitoring the quality of the water they deliver for human consumption. The Grand Ducal Regulation of 7 October 2002, which implements Directive 98/83/EC on the quality of water intended for human consumption requires drinking water suppliers to audit their infrastructure and assess the state of water resources. A total of 97 of the 116 municipalities and the seven inter-municipal syndicates had finished their audit by the end of March 2010. Under the terms of the Water Act, all bodies of groundwater must be protected, improved and restored to "good status" by the end of 2015. The main groundwater pollutants are nitrates and pesticides. At a national level, the nitrogen content has decreased considerably since the early 1990s, dropping from 200kg N/hectare to 111 kg N/hectare in 2004 (the last available year). However, a recent study showed that 40 % of the surface area that drains into drinking water sources discharges water containing 25-50 mg/L of nitrates. Moreover, some of the sources show a clear trend towards deterioration. At a national level, half of the nitrogen input comes from the use of chemical fertilizers, and a third from livestock effluents; the rest is atmospherically deposited. In up to 90 % of the monitored groundwater sampling sites pesticides are detected, sometimes at concentrations that exceed the threshold value of 100 mg/liter. This indicates that not only is the Luxembourg sandstone aquifer more vulnerable to pollution than the aquifers of neighboring regions, but also that there is a lack of protection for the abstraction areas.

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Directive 2007/60/EC of the European Parliament and of the Council of 23 October, 2007 on the assessment and management of flood risks; aims to manage and reduce the risk of floods, particularly along rivers and in coastal areas;

Directive 98/83/EC of 3 November, 1998 on the quality of water

Belgium

Belgium is a small country with a surface area of 30,528 km^2 in north-western Europe and 3,454 km² of the North Sea. It shares borders with the Netherlands, Germany, Luxembourg, and France and has a coastline of 73.1 km along the North Sea. Although Belgium is highly urbanized and is the third most densely populated country in Europe, forests and other natural areas have remained relatively stable (23 % of the territory). Its latitude and the proximity of the sea warmed by the Gulf Stream give Belgium a temperate maritime climate characterized by moderate temperatures, prevailing southerly to westerly winds, abundant cloud cover, and frequent precipitation. Summers are relatively cool and humid, and winters are relatively mild and rainy. Impact, vulnerability and adaptation assessments have been funded and piloted at the regional and federal levels. Belgium submitted its updated Nationally Determined Contribution (NDC) as an EU Member State in 2020 and its Seventh National Communication in 2017.

The geographical location of Belgium

Climate

Belgium has a temperate maritime climate characterized by moderate temperatures, prevailing southerly to westerly winds, abundant cloud cover, and frequent precipitation. Summers are relatively cool and humid, and winters are relatively mild and rainy. Observed temperatures have revealed a significant upward trend since the end of the 19th century. In recent years, the temperature has shown a constant increase of 0.4 °C per decade. Precipitation in Belgium reveals high variability over time, with a slow but significant rising trend. Significant increases in annual accumulations have been observed (about 7%), as well as winter and spring accumulations (approximately 15%). The

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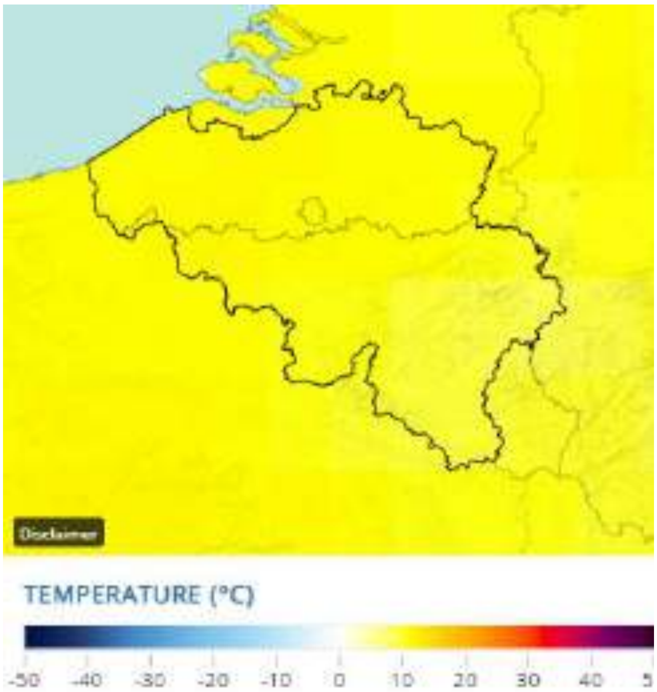
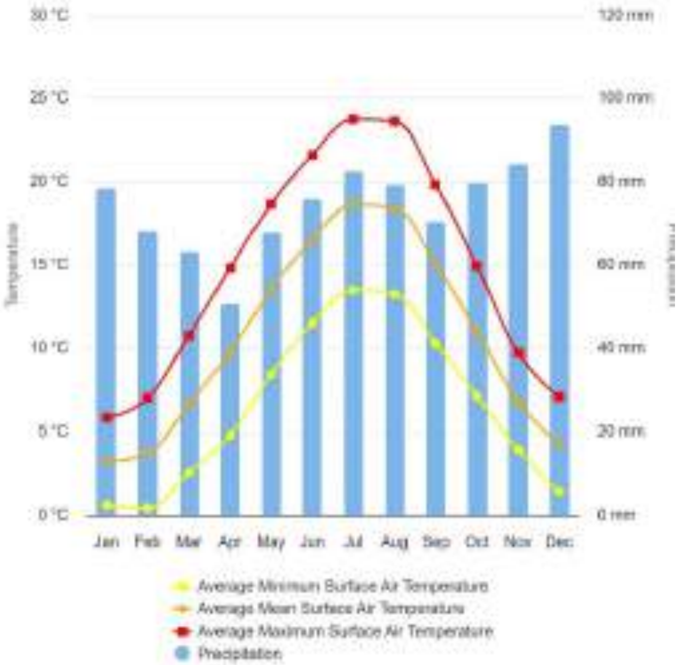
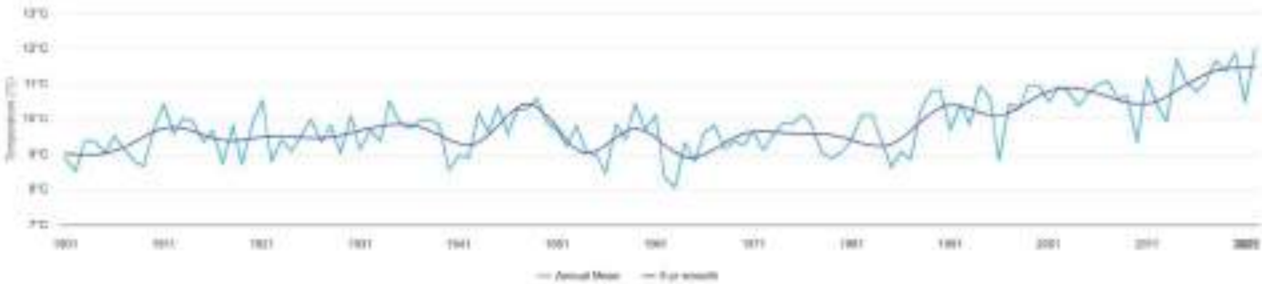
number of days with heavy precipitation and the maximum amount of precipitation in 5, 10, and 15 days have also increased significantly.



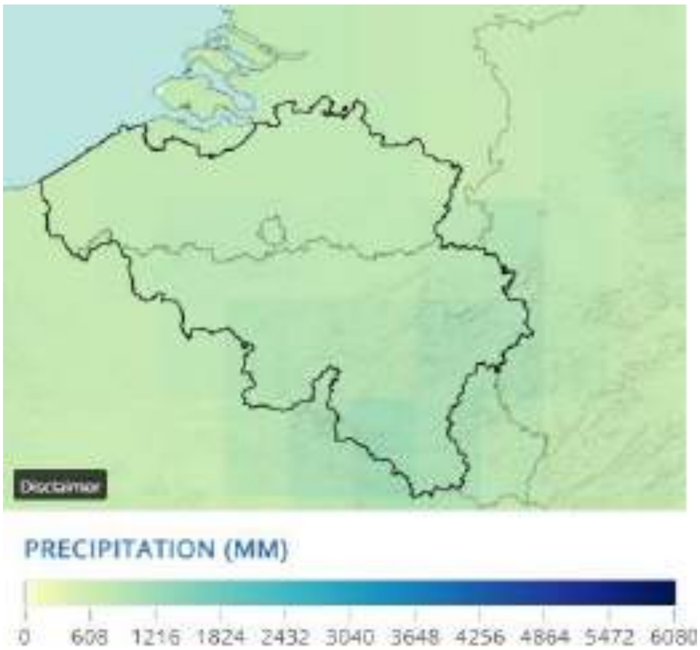
Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Belgium



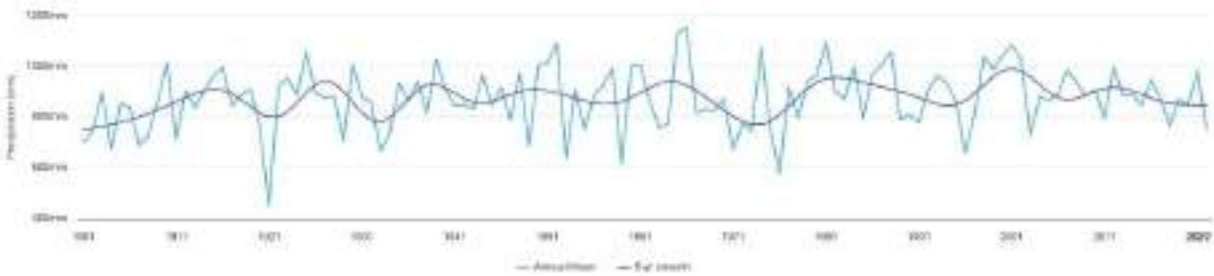
Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; Belgium



Observed Annual Average Mean Surface Air Temperature 1991-2022; Belgium



Observed Climatology of Precipitation 1991-2020; Belgium



Observed Annual Precipitation 1991-2022; Belgium

Hidrology and water quantity

Belgium's water resources are distributed among five river basins, the two main ones being the Maas River (known in French as the Meuse) and the Scheldt (known in French as the Escaut); both have their source in France and flow into the sea in the Netherlands. The major aquifers are located in Wallonia. Belgium does not face water stress despite its high-density population. Internal water availability is around 12,000 million m^3/year (average 1990- 2004), or 1,168 m^3/capita/year. The yield of groundwater is around 900 million m^3, exploited at a rate of 75 %. This picture hides strong regional disparities, with the North distinct from the South. Wallonia satisfies 55 % of the country's drinking water, but includes only 37 % of the population. Flanders and Brussels are dependent on drinking water from Wallonia, at levels of 40 and 98 %, respectively. The picture is further complicated by the strong dependence of the Netherlands on the Maas for its drinking water. Water Withdrawals in Belgium are 9.03 km^3/yr. Distribution of water use by sector is: agricultural use: 4; %; domestic use: 11 %; industrial use: 85 %.

Water quality

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The environment in Belgium is exposed to intense pressures from human activities such as urbanization, a dense transportation network, industry, extensive animal breeding, and crop cultivation. Air and water pollution also have repercussions for neighboring countries. Uncertainties regarding federal and regional responsibilities (now resolved) have previously slowed progress in tackling environmental challenges. The high population density, together with a very high degree of urbanization and industrialization, has had effects on the overall environmental quality. In the 1996 Habitat report, it was stated that environmental degradation of rivers, watercourses, and coastal areas of soil and subsoil (including aquifers), air, and green and forest areas were all serious problems in Belgium, as was waste. The oxygen condition of surface waters (O_2, COD) is improving and nutrient concentrations (except for NO_3-N) are falling. Several industrial sectors have made a major effort to reduce their wastewater loads, and the expansion of wastewater treatment plants has led to the reduction of wastewater loading by households. However, many measuring points do not yet satisfy basic quality standards, and only about ten measuring points have good physicochemical conditions for all parameters. Industrial companies should be further disconnected from the sewage network and discharge permits should be adjusted in accordance with ecological standards. The additional connection of households to wastewater treatment plants should also further decrease wastewater loads. Nitrate concentrations remain a problem, for which agriculture, in particular, will have to find a solution. The proportion of measuring points with extremely bad to very bad biological quality (BBI) is falling sharply and the proportion of measuring points with good to very good BBI is increasing (30 % in 2002). However, according to the VLAREM standards, all measuring points must have a BBI of at least 7. In addition, the ‘standstill principle’ (no deterioration of the present situation) is often not applicable. There is still much to be done to achieve a good ecological situation in all watercourses by 2015 (*European Water Framework Directive*). Not only must the physico-chemical quality of the water be improved, but the quality of the sediment and the natural morphology of the watercourses must also be restored.

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France

The surface area of mainland France (550,000 km^2) is the largest of the European Union countries (around 13 % of the EU area). Located between the Atlantic and the Mediterranean, between latitudes 41°N and 51°N, France has around 3,200 km of coastline. France is a country of average elevation, and plains and hills occupy two-thirds of the territory. However, it has two mountain barriers, one in the east and the other in the south: The Alps and the Pyrenees. Mont Blanc (4,810 m), the highest point in France, is located in the Alps, on the border with Italy. The Massif Central, in the center of the country, plays a role in dispersing water to the four major basins: The Seine to the north, the Loire to the northwest, the Rhone to the east, and the Garonne to the southwest. Nearly 60% of the mainland surface area is used for agriculture (33 million hectares), 34 % is forests and natural or semi-natural environments (19 million hectares), while just under 6 % corresponds to urbanized land (3 million hectares). The population of France is over 67 million (2020). The French economy is mainly a service economy, with the tertiary sector accounting for 76.7 % of the labor force, while the primary sector (such as agriculture, fishing) accounts for only 2.8 %. France is vulnerable to the impacts of climate change, which include an increase in temperature, an increase in the risk of heat waves, more intense rainfall, an increase in the risk of flooding, rising sea levels, and uncertain changes in the frequency and severity of storms. Through the National Climate Change Adaptation Plan, France aims to protect the French population against extreme weather events and also to build resilience to climate change in the main sectors of the economy (agriculture, industry, and tourism).

The geographical location of France

Climate

Mainland France enjoys a temperate climate. However, regions experience climates that vary according to their latitude, altitude and their proximity to the sea and to the three major mountain ranges (Pyrenees, Massif Central, Alps). There are five main types of climates in mainland France: oceanic, altered oceanic, semi-continental, mountainous, and Mediterranean.

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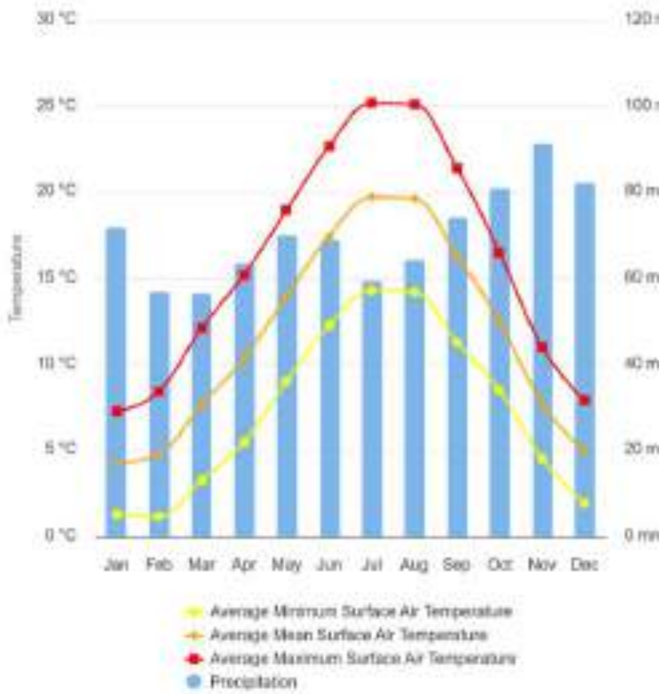
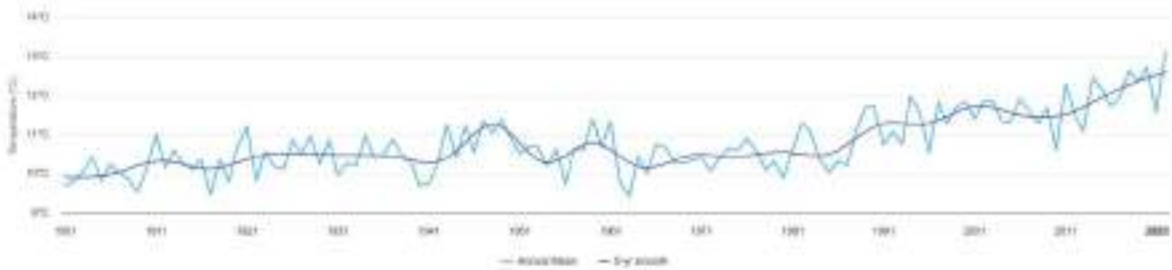
Observed Climatology of Average Mean Surface Air Temperature 1991-2020; France

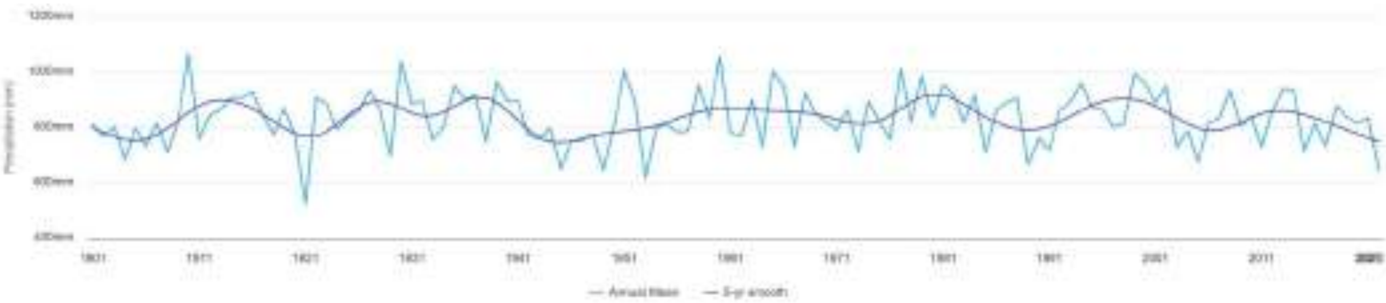


Monthly Climatology of Average Minimum, Mean, Maximum Surface Air Temperature and Precipitation 1991-2020; France



Observed Annual Average Mean Surface Air Temperature 1991-2022; France

Observed Climatology of Precipitation 1991-2020; France



Observed Annual Precipitation 1991-2022; France

Hydrology and water quantity

There are six major river basins in France: the Adour-Garonne, the Artois-Picardy, the LoireBritanny, the Rhine-Meuse, the Rhone-Mediterranean and the Seine-Normandy. These basins are managed by separate basin agencies that were established by the 1964 Water Law and further reinforced by the 1992 Water Act. Water resources in France are as follows:

Internal Renewable Water Resources (IRWR), 1977-2001 (km^3)	
Surface water produced internally	176
Groundwater Recharge	100
Overlap (shared by groundwater and surface water)	98
Total IRWR	178
Per capita IRWR, 2001 (m^3)	2,991
Natural renewable water resources	
Total, 1977-2001 (km^3)	204
Per capita, 2002 (m^3 per person)	3,414
Annual River Flows	
From other countries (km^3)	11
To other countries (km^3)	150

For about thirty years water needs in France have grown steadily, particularly those of agriculture and towns. Total domestic water use is about 6 billion m^3 or only about 3% of total runoff (191 billion m^3), 62 % of drinking water supply is from groundwater, and 38 % from surface water.

Water Withdrawals	
Year of Withdrawal Data	1999
Total withdrawals (km^3)	32
Withdrawals per capita (m^3)	547
Withdrawals (as a percentage of Actual)	
Renewable Water Resources	16 %
Withdrawals by Sector (as a percent of total)	
Agriculture	10 %
Industry	72 %
Domestic	18 %

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Water quality
There has been a change in nitrate levels in water, although this varies considerably over time and space, and notably in tap water, for which the World Health Organisation (WHO) has set an acceptable threshold of 50 mg/l. Estimates show that responsibility for nitrogen discharges into the natural environment lies with agricultural activities for 55 %, domestic activities for 35 %, and industrial activities for 10 %. The quantity of chemical nitrogenous fertilizer spread on a national basis comes to 90 kg/ha/year, in addition to 50 kg/ha/year for livestock farming effluent. The highest levels can be seen in cereal crop and market gardening areas and in intensive livestock farming areas, where the production of farm fertilizer spread often exceeds the purification capacities of soil and crops. Although current knowledge is still incomplete, phosphorous is deemed to be the key factor for managing eutrophication for internal soft water bodies. The estimates made attribute 25 % of discharges into water to agricultural activities, 50 % to domestic activities and 25 % to industrial activities. The quantities of phosphorous spread come to around 30 kg/ha/year, of which 60 % is from chemical sources. These chemical phosphorous inputs have fallen 50 % over 20 years. However, phosphorous inputs from farm fertilizers are concentrated in areas with intensive livestock farming, where phosphorous levels in soils are already high. A report published by the French Environment Institute (IFEN, 2006) reveals that 96 % of controls on surface waters and 61 % of controls on ground waters indicate pesticide contamination.

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Poland

The Republic of Poland is a country located in Central Europe that links the forested lands of northwestern Europe to the sea lanes of the Atlantic Ocean and the fertile plains of the Eurasian frontier. The country covers an area of 312,696 km^2 and has a population of approximately 38 million (2020) people. Poland is vulnerable to the impacts of climate change, such as an increase in the frequency of extreme weather events, including floods, droughts, and hurricanes, sea level rise, and an increase in temperature and precipitation, which pose a significant impact on Poland's agriculture, health, forestry, and biodiversity.

The geographical location of Poland

Climate

The Polish climate is characterized by a high degree of weather variability and significant changes in the course of each season. Annual average air temperatures range from 5°C to nearly 9°C. The warmest area is the south-western part of Poland, while the coldest is the north-eastern part of the country and in the mountain areas. A distinctive feature of Poland's climate characteristic is the number of cold days (with maximum temperatures below 0°C) the country experiences, mostly in January. Poland is located in a moderate climate zone and is dominated by four distinct seasons: Autumn from September to November, Winter from December to February, Spring from March to May, and Summer from June to August. Poland has two additional periods, early spring and early winter. January and February are typically the coldest months. Agricultural cropping seasons typically occur from spring to autumn.

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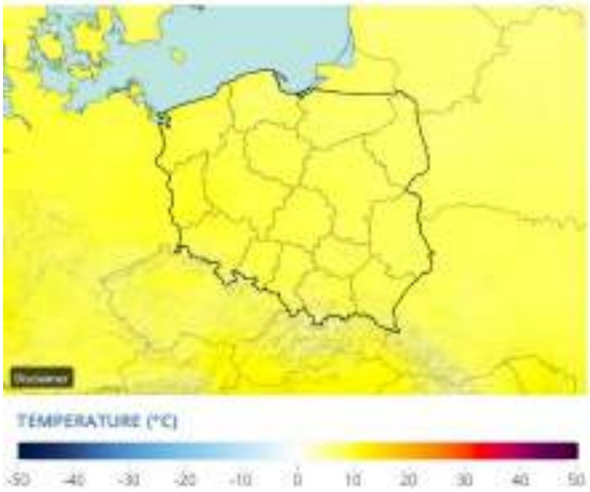
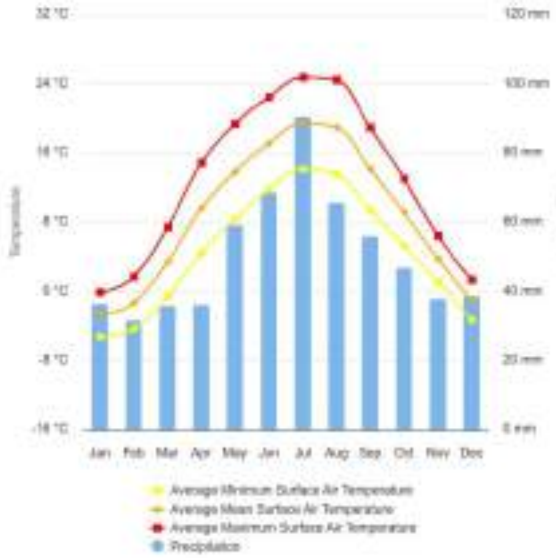


Observed Climatology of Average Mean Surface Air Temperature 1991-2020; Poland



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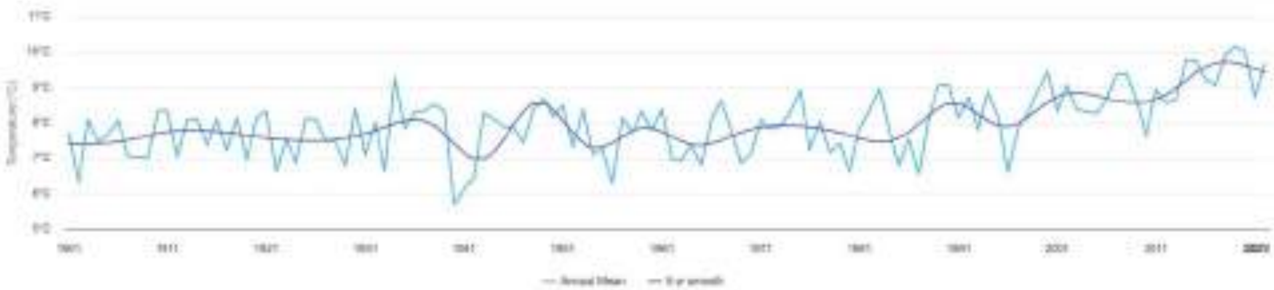

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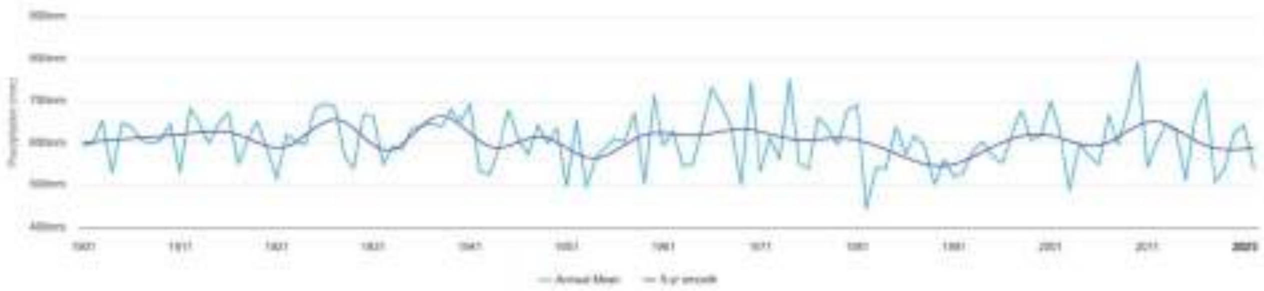

Observed Annual Precipitation 1991-2022; Poland

Hidrology and water quantity

Poland has a mean annual water resources per capita of approximately 1,600 m^3, almost three times less than the mean value for Europe. In addition, the available resources are subject to great year to-year variability. Devastating floods and local water scarcities are frequent. The longest rivers are: the Vistula (Polish: Wisła), 1,047 km long; the Oder (Polish: Odra) which forms part of Poland's western border, 854 km long; its tributary the Warta, 808 km long; and the Bug, a tributary of the Vistula, 772 km long. The Vistula and the Oder flow into the Baltic Sea, as do numerous smaller rivers in Pomerania. The Łyna and the Angrapa flow by way of the Pregolya to the Baltic, and the Czarna Hańcza flows into the Baltic through the Neman. While the great majority of Poland's rivers drain into the Baltic Sea, Poland's Beskids are the source of some of the upper tributaries of the Orava, which flows via the Váh and the Danube to the Black Sea. The eastern Beskids are also the source of some streams that drain through the Dniester to the Black Sea. Poland's rivers have been used since early times for navigation. The Vikings, for example, traveled up the Vistula and the Oder in their longships. In the Middle Ages and in early modern times, when the Polish-Lithuanian Commonwealth was the breadbasket of Europe, the shipment of grain and other agricultural products down the Vistula toward Gdańsk and onward to Western Europe took on great importance. With almost ten thousand closed bodies of water covering more than 10,000 m^2 each, Poland has one of the highest numbers of lakes in the world. In Europe, only Finland has a greater density of lakes. The largest lakes, covering more than 100 km^2, are Lake Śniardwy and Lake Mamry in Masuria, and Lake Łebsko and Lake Drawsko in Pomerania. In addition to the lake districts in the north (in Masuria, Pomerania, Kashubia, Lubuskie, and Greater Poland), there is also a large number of mountain lakes in the Tatras, of which the Morskie Oko is the largest in area. The lake with the greatest depth – of more than 100 m – is Lake Hańcza in the Wigry Lake District, east of Masuria in Podlaskie Voivodeship. Among the first lakes whose shores were settled are those in the Greater Polish Lake District. The stilt house settlement of Biskupin, occupied by more than one thousand residents, was founded before the seventh century BC by people of the Lusatian culture. Water withdrawals in Poland total around 16.2 km3/year. Water use by sector is: for agricultural use, 8 %; for domestic use, 13 %; for industrial use, 79 %.

Water quality

Water quality management is one of the key issues creating problems for people's livelihoods and the environment. However, water and air pollution affect the entire country, however. A 1990 report found that 65 % of Poland's river water was so contaminated that it corroded equipment when used in industry. After absorbing contaminants from the many cities on its banks, the Vistula river was a major polluter of the Baltic Sea. River water could not be used for irrigation. In 1990, about half of Poland's lakes had been damaged by acid rain, and 95 % of the country's river water was considered undrinkable. Because Polish forests are dominated by conifers, which are especially vulnerable to acid rain, nearly two-thirds of forest land had sustained some damage from air pollution by 1990. In 1989, Polish experts estimated total economic losses from environmental damage at over US$3.4 billion, including soil erosion, damage to

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resources and equipment from air and water pollution, and public health costs. The situation has improved since 1989 due to a decline in heavy industry and increased environmental concern on the part of post-Communist governments. Air pollution nonetheless remains serious because of sulfur dioxide emissions from coal-fired power plants, and the resulting acid rain has caused forest damage; water pollution from industrial and municipal sources is also a problem, as is disposal of hazardous wastes. Pollution levels should continue to decrease as industrial establishments bring their facilities up to EU standards but at a substantial cost to businesses and the government.

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