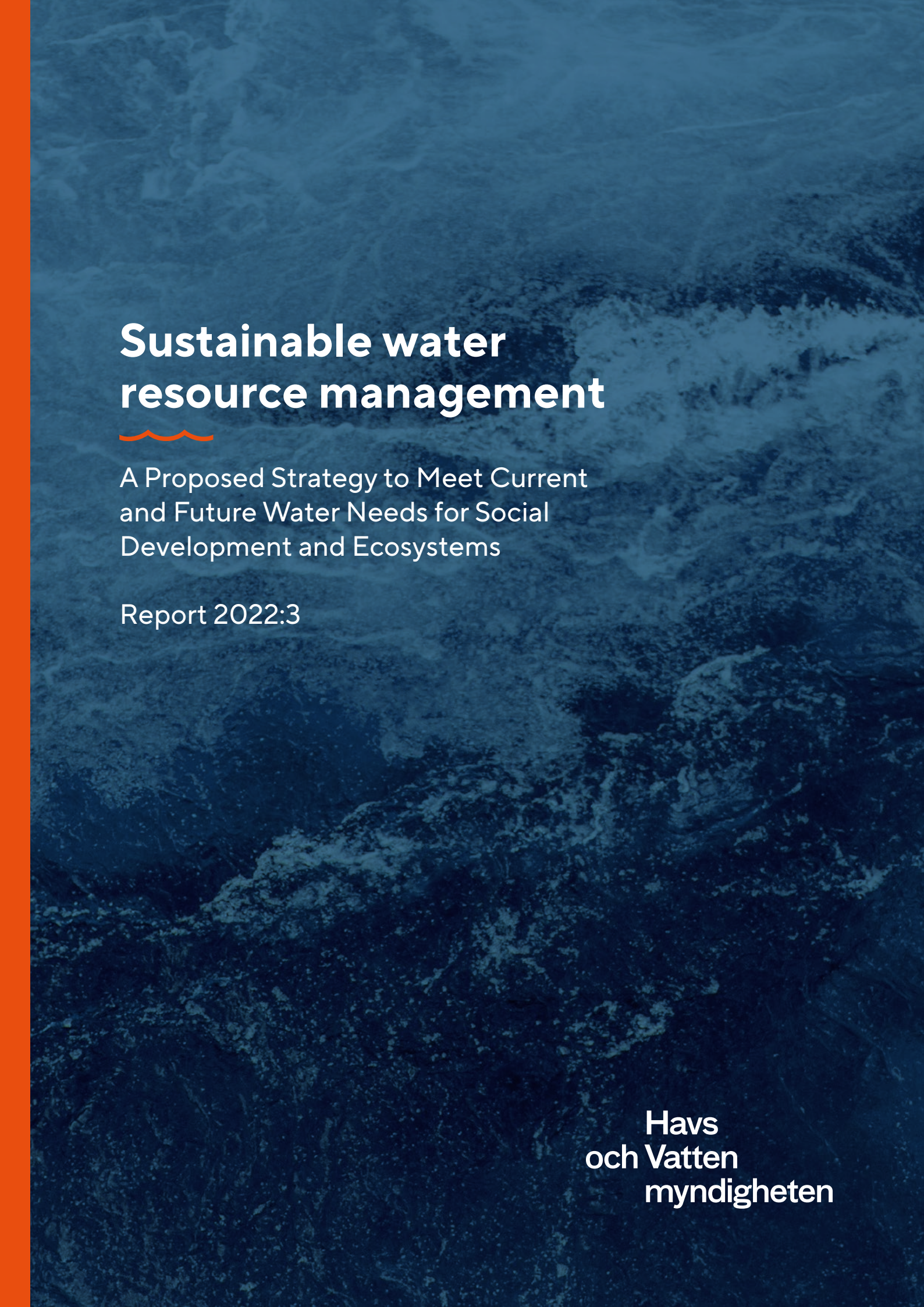

Sustainable water resource management

A Proposed Strategy to Meet Current and Future Water Needs for Social Development and Ecosystems

Report 2022:3

Havs och Vattenmyndigheten

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Water – a strategic resource for society and ecosystems

The Swedish Agency for Marine and Water Management is an administrative authority with responsibility for issues relating to the conservation, restoration and sustainable use of lakes and watercourses. In order to strengthen a holistic perspective in the management of our water resources, the agency has initiated analytical work in which we clearly highlight water as a resource as well as its use, and emphasise the importance of planning and managing water resources on the basis of catchment area.

The objective of the work has been to develop and propose a strategy for the sustainable management of water resources that can ensure the combined water needs of society and nature in a changing climate. The ambition has not been to identify exact solutions but instead to identify the development needs in various areas.

The proposed strategy is based on our analysis from different perspectives of Sweden's water resources. We have identified obstacles and opportunities within existing governance, regulation and organisation, as well as ways of working, under the frameworks of existing and future needs.

The work of the agency has included dialogues with representatives from national and regional authorities, municipalities, universities, interest groups and operators. The dialogue and analysis were initiated during the Almedalen Week of 2019, and the dialogue has been of great value in the implementation of the work. Since then, many parallel initiatives have been implemented that have contributed to the issues included in the report. It is worth mentioning that the government has appointed a national coordinator for business sector water management and has initiated work to draw up a strategy for efficient and sustainable water management. Other examples include the IVA project Sustainable water supply – access to clean water in a changing climate[1] and Sydvatten's work on Climate-resilient water[2].

We found that there is no integrated management of Sweden's water resources at local, regional and national level. Water management under the Water Administration Regulation focuses on ecological water quality and drinking water supply. Limited attention is paid to the other needs of society for the utilisation of water quality, water quantity and water-related natural and cultural values.

The dialogue and our analysis clearly show that the water resource issue is a societal issue that can be viewed from many different perspectives and that it attracts widespread interest. We hope that this report will further increase this interest and therefore contribute to strengthened and broadened water management – sustainable water resource management. This report provides a comprehensive overview of Swedish freshwater resources, their exploitation, legislation and a proposed strategy for sustainable water resource management.

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1) IVA 2021. Agenda for sustainable water supply. Report from the IVA project Sustainable Water Supply – Access to clean water in a changing climate.

2) Sydvatten 2019. Climate-resilient water

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Some key concepts

Catchment area – Catchment area perspective

A catchment area is the area of land surrounding a watercourse from which water drains into the watercourse. The catchment area is bounded by ridges, which divide the flow of rain and meltwater between adjoining catchment areas. The boundary of a catchment area is the watershed. The catchment area perspective means that everything that takes place upstream of a certain point in the watercourse, such as discharges or similar, can affect the conditions downstream. It is therefore necessary for catchment areas to form the basis for decisions on watercourse management in order to meet different water needs within the areas while ensuring good water quality.

Biodiversity

Biodiversity means the variability among living organisms from all sources and the ecological complexes of which they are part. From a landscape perspective, biodiversity is the variability among the landscape's habitats and species as well as the genetic variation within species. Biodiversity includes wild plants, animals and fungi as well as cultivated plants, domestic animals and their habitats.

Blue-green infrastructure

Blue-green infrastructure is defined as ecologically functional networks of habitats and structures, natural areas and landscape elements that are designed, used and managed in a way that promotes socially important ecosystem services throughout the landscape, such as water purification, air quality and climate adaptation. The network of green (land) and blue (water) areas improves environmental conditions and therefore human health and quality of life. It also supports a blue-green economy, creates job opportunities and improves biodiversity.

Ecosystem

An ecosystem is a bounded area of nature and includes all living things and habitats within the area. An ecosystem can be large or small depending on chosen study object, such as the ecosystem of an ocean or of a small pond.

Photo: Ingemar Pettersson

Ecosystem services

Ecosystem services describe the direct and indirect contribution of ecosystems to human well-being. Ecosystem services describe ecosystems from a human perspective and clarify human dependence on nature. Ecosystem services are often divided into four categories: supporting, regulating, provisioning and cultural.

Sustainable water resource management

Sustainable water resource management refers to experience-based and knowledge-based management of the entire water resource within a catchment area in a way that is of benefit to both

the environment and society, now and in the future. This means that the management must ensure that the overall water needs of society are met while maintaining or improving the condition of the water resource ecologically, environmentally and hydrologically. The understanding of sustainable water resource management is primarily based on the so-called Dublin Principles[3], which indicate that water is an economic commodity and an entitlement, that water should be exploited but not overexploited, and that water should be managed in collaboration with those affected. The main difference between sustainable water resource management and water management as implemented under the Water Administration Regulation is that the former has a much greater focus on water as a resource, the combined water needs of society and nature, catchment area management, participation and collaboration.


Photo: Pontus Nilsson

Nature-based solutions

Nature-based solutions (NbS) make use of the ability of ecosystems to address different societal problems or attempt to imitate nature (biomimicry) for the same purpose. Nature-based solutions can help strengthen ecosystem services, which in turn can create resilience to change and contribute to human well-being. The European Commission defines NbS as cost-effective solutions to societal challenges that are inspired and supported by nature and simultaneously provide environmental, social as well as economic benefits that collectively build resilience to climate change.[4]

Water scarcity

Water scarcity occurs when the availability of freshwater cannot meet demand. For example, water scarcity can occur during periods of hot weather and low rainfall, when demand is often high and supply is limited. Water scarcity can be linked to surface water, soil water and/or groundwater reservoirs. As different reservoirs react differently to changes in the water balance, scarcity in one reservoir does not necessarily mean scarcity in the others. For example, there may be groundwater scarcity at the same time as adequate surface water. To avoid jeopardising a reservoir's capacity to provide water in the long term, the amount of water that can be withdrawn is not determined by its size, but how quickly it can be replenished.

Water abstraction

Water abstraction means drawing off water, permanently or temporarily, for domestic, industrial or agricultural use from surface water or groundwater. Water abstraction constitutes a so-called water activity that is covered by the rules in Chapter 11, Environmental Code. Water abstraction affects the water balance in an area from the point of abstraction and downstream. In Sweden, hydropower is not usually considered as water abstraction, but a regulation of water flow.

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3) International Conference on Water and the Environment (ICWE), Dublin 1992

4) Nature-based solutions in Europe, EEA 2021

Photo: Matt Hardy

Why is sustainable water resource management needed?

Good access to good quality water is a prerequisite for the development of society. Water is a strategic resource for society and its development and a necessity for functioning ecosystem services, energy production, green industries, industry and households. The qualitative and quantitative properties of water affect biodiversity and ecosystems as well as how it is used. Quality and quantity therefore need to be managed in a context. Climate change and societal changes affect the water cycle and increase the problems of water scarcity and flooding. Too little as well as too much water pose a threat to important societal functions.

Water has been and is used as a resource for many different purposes, which has been essential for social development. The water landscape is naturally in a state of constant change, but it is also affected by climate and human intervention. These impacts occur on different scales of time and space. Effects of impacts can be almost instantaneous but also gradual over a very long period of time. An impact at one point can have an effect both downstream and upstream within a catchment area. This means that effects of impacts that accumulate within the catchment can result in changes at system level.

Poor upstream water resource management contributes to downstream pollution in coastal and marine areas due to, for example, eutrophication, plastic waste and hazardous substances. Good water resource management therefore also contributes to achieving objectives for coastal and marine management by taking a holistic approach from source to sea.

Sweden basically has a good supply of water, but conditions vary greatly. In particular in south-eastern Sweden, there is a need to balance between different societal interests on different scales. Clear objectives and strategies are needed for sustainable water resource management in order to safeguard the combined water needs of society and nature, as well as to reduce the risks of drought and flooding. Strategic proactive planning is needed to manage trade-offs between different interests and needs in order to prevent risks and threats, as well as simultaneously take advantage of the potential opportunities presented by change.

Policy objectives

National policy emphasises responsibility for the future, in Sweden and the world around us. This means implementing strong initiatives to achieve clean seas, lakes and watercourses, to tackle eutrophication, environmental pollutants, litter and other threats to water resources. Poor upstream water resource management can lead to problems with water quality and quantity downstream. Good water resource management therefore also contributes to the potential for achieving objectives for coastal and marine management by taking a holistic approach from source to sea. [5,6]

Agenda 2030

Agenda 2030, with the 17 global Sustainable Development Goals, is a general international agenda for a shift to a sustainable society. Sweden's commitment is to implement Agenda 2030 for sustainable development in its three dimensions: economic, social and environmental. This will be achieved through a coherent policy at national and international levels, in which all the goals are viewed as a whole.[7]

The goals in the agenda are all linked to water, as sustainable, aquatic ecosystems represent a basic precondition for sustainable social and economic development. Goal 6: to ensure availability and sustainable management of water and sanitation for all, and Goal 14: to conserve and sustainably use the oceans, seas and marine resources for sustainable development, are particularly relevant in providing guidance for the Swedish Agency for Marine and Water Management's activities. Goal 13 on combating climate change and Goal 5 on gender equality are examples of other important goals in the agenda that guide the Agency. The implementation of the goals in Agenda 2030 in Sweden emphasises a holistic perspective as well as the importance of coordination and collaboration between actors throughout society in accordance with Goal 17: implementation and global partnership.[8] At a national level, the agenda's environmental dimension reflects the environmental objectives that the Swedish parliament has adopted.

The EU's Water Framework Directive and OECD principles

Water management in Sweden is often equated with the Swedish implementation of the EU's Water Framework Directive (WFD). The Directive aims to establish a framework of harmonised rules within the EU in order to ensure or improve water quality in lakes, watercourses, coastal waters and groundwater. Its aim is to reduce pollutants and promote sustainable water use. The focus is on water quality as an indicator of functioning ecosystems. Water quantity is emphasised only for groundwater, although a prerequisite of the Directive's ecological objectives is a good quantity of surface water in order to ensure a good water environment.

The objective of the Water Framework Directive is for EU water bodies to achieve "good status" where possible, and otherwise not to deteriorate. This means restoring and protecting ecosystems in and around water bodies, as well as reducing pollutants. At the same time, the Directive was also introduced in order to ensure sustainable water use for people and businesses in the long term. For this reason, heavily modified waters are an alternative environmental objective in individual water bodies, but there is also the possibility to apply a lower level of ambition in the form of less stringent requirements where it is deemed that use of the water resource in question is of great importance to society.

Consideration and trade-offs need to be made in water management with regard to society's overall water needs for various purposes. However, there are instances where

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5) The Swedish Agency for Marine and Water Management's operational strategy 2021–2023

6) Granit, J., Liss Lymer, B.; Olsen, S., Tengberg, A; Nõmmann, S.; Clausen, T. J. (2017): A Conceptual Framework for Governing and Managing Key Flows in a Source-to-Sea Continuum. Water Policy.

7) Agenda 2030 and the Global Sustainable Development Goals – Regeringen.se

8) Government Bill 2019/20:188

consideration has not been given to national, regional and local societal needs for water. A common perception among societal actors is that too little consideration has been given to societal needs for water resources. Trade-offs need to be made in a transparent manner, in dialogue with the parties affected, and with consideration given to objectives and conditions at national, regional and local level. At the same time, economic and social considerations must not lead to an erosion of or lack of measures to improve water-dependent ecosystems.

Sustainable water management must not only protect and strengthen ecosystems and ecosystem services but must also contribute to economic and social development. The starting point needs to be the combined water needs of society and nature. Quality and quantity therefore need to be managed in context. The need to take a resource perspective and manage quality and quantity together has broad support in the research as well as in the conclusions of several global environmental conferences. The OECD has drawn up a set of principles based on scientific evidence for what it calls Integrated Water Resource Management (IWRM)[9]

The OECD principles have primarily been incorporated into the EU common guidelines[10] for the implementation of the Water Framework Directive and are formulated as:

1. Integration of environmental objectives that include goals for water quality, water quantity and ecology in order to protect valuable aquatic ecosystems and to ensure overall good status for other waters.
2. Integration of all water resources in lakes, watercourses, wetlands and coastal ecosystems at catchment area level.
3. Integration of all water use, functions and values into a common policy framework.
4. Integration of different disciplines, analyses and expertise in order to assess the impact and its effects on water resources, as well as to identify measures to achieve the goals of the Directive in the most cost-effective way.
5. Integration of water legislation into a common and coherent framework.
6. Integration of all essential aspects of management and ecology that are relevant to sustainable planning at catchment area level.
7. Integration of a broad spectrum of measures, including pricing and economic and financial instruments, into a common management strategy in order to achieve the environmental objectives of the Directive.
8. Integration of relevant stakeholders and civil society in decision-making by promoting transparency and by making information available to the public, as well as by providing opportunities for stakeholders to participate in the planning process for catchment areas.
9. Integration between and within different levels of decision-making (national-regional-local) that affect the water resource or water quality.
10. Integration of management in international catchment areas.

Current management

The water resource issue involves many actors. Municipalities are responsible for planning land and water use with guidance support from the Swedish National Board of Housing, Building and Planning. The county administrative boards have a range of relevant tasks, not least to draw up regional water supply plans and plans for green infrastructure. Five county administrative boards are also water authorities with responsibility for implementing the Water Administration Regulation and the Water Framework Directive,

9) https://www.oecd.org/governance/oecd-principles-on-water-governance.htm

10) River basin management – Water – Environment – European Commission (europa.eu)

with guidance support from SwAM and the Geological Survey of Sweden (SGU). SwAM and SGU are also responsible for the environmental objectives related to surface and groundwater respectively. The Swedish Food Agency has overall responsibility for drinking water issues and the Swedish Civil Contingencies Agency (MSB) is responsible for the implementation of the EU Floods Directive. Other important authorities are the Swedish Meteorological and Hydrological Institute (SMHI) for knowledge and methodological support for weather, water and climate, as well as the Swedish Board of Agriculture and the Swedish Forest Agency with knowledge of each sector's needs. The diversity of authorities involved in the implementation of water management means that the management is perceived as fragmented, not least by water resource users.

Water resource issues are raised when activities apply for a permit under Chapter 11, Environmental Code. However, only the current activity is dealt with in the assessment. There is no legal support for conducting a coherent examination of precautionary measures and protective measures for an entire watercourse with all the activities that have an impact on the watercourse.

The implementation of the national plan for the environmental adaptation of hydropower has begun and the first reassessments of environmental permits are expected in 2022. The review process and the follow-up of implemented measures will lead to an increase in knowledge of many watercourses and water systems. There is a need to ensure that new knowledge and newly gained experience are utilised in water management.

Climate change

There is an extensive build-up of knowledge in progress about how climate change affects our water resources and what will be needed terms of climate adaptation to meet the demands of climate change. The Government has identified[11] seven societal challenges particularly important to consider in relation to climate change. Three of these are directly linked to changes in terms of there being too much or too little water.

The main climate challenges facing the Government

Climate adaptation measures should be taken in several sectors of society and geographical areas. Based on the anticipated consequences for society, the following areas are of particular importance for the continued climate adaptation work:

- Landslides, debris flows and erosion that threaten communities, infrastructure and businesses.
- Floods that threaten communities, infrastructure and businesses.
- High temperatures that pose risks to the health and well-being of people and animals.
- Water supply shortages for individuals, agriculture, and industry.
- Biological and ecological impacts that affect sustainable development.
- Impact on domestic and international food production and trade.
- Increased incidence of pests, diseases and invasive non-native species that affect people, animals and plants.[12]

11) Swedish National Adaptation Strategy, Government Bill 2017/2018:163

12) Swedish National Adaptation Strategy, Government Bill 2017/2018:163

Water supply shortages for individuals, agriculture, and industry

The droughts of recent years have shown that Sweden lacks coherent management of available water resources at local, regional and national levels. Periods of water scarcity in different areas have affected agriculture, the national supply of electricity and drinking water, as well as the flora and fauna of our aquatic environments. Water has been insufficient to meet the various needs of society and the environment. An equitable distribution and efficient use of water are prerequisites for a sustainable society. A society in which today's needs are met without risking the ability of future generations to meet their needs. Water resources need to be managed primarily within the catchment area, but the benefits from water, such as food and energy, extend throughout the country and beyond.

Floods that threaten communities, infrastructure and businesses

MSB has identified 25 urban centres in Sweden that have been classified as areas with significant flood risk due to high flows or elevated water levels and where the consequences of a flood are expected to be significant[13]. Many such areas coincide with areas where there will be an increase in the highest high water flows in lakes and rivers due to climate change.

Torrential rainfall also causes flooding, primarily in urban environments, but agriculture is also affected. We are reminded of this more and more often, for example in Copenhagen in 2011, Malmö in 2014, Hallsberg in 2015, and most recently in Gävle in 2021. There is torrential rainfall throughout Sweden but it is most common in the south-west. Climate change is expected to increase the frequency and intensity of torrential rainfall by between 10 and 40 per cent depending on climatic developments[14]. Preventive planning and work is needed to reduce the risks and effects of flooding in the countryside and in urban environments.

Flooding Gävle 2021, Södra Kungsvägen.

13) Review of areas of potential significant flood risk, MSB 2018

14) Rainfall extremes in current and future climates. Analyses of observations and future scenarios. Jonas Olsson et al, SMHI Climatology No 47, 2017.

Landslides, debris flows and erosion that threaten communities, infrastructure and businesses

A changing climate with increased flows, more intense torrential rainfall and changing soil conditions can lead to an increased risk of erosion, landslides and debris flows in large parts of the country. Adapted water management and the application of nature-based solutions can facilitate the assessment of soil conditions and, if possible, ensure them for both existing and planned development[15].

Results from the dialogue

The dialogue showed that the water resource issue attracts widespread interest from all actors. The water resource and its management is a societal issue that can be viewed from many different perspectives. Reducing the risks of water scarcity and flooding is first and foremost a planning issue. This means that the water resource issue needs to be managed sustainably over time and coordinated geographically, mainly on a catchment area basis, as well as sectorally in order to collectively manage all the different water needs.

The dialogue expressed the view that there is no integrated management of Sweden's water resources at local, regional and national level. The water management carried out under the Water Administration Regulation focuses on water quality and the supply of drinking water, and primarily considers water quantity in cases where it can have an impact on water quality. Criticism of shortcomings in the Water Framework Directive can be interpreted as an incomplete implementation of the Water Framework Directive in Sweden or as insufficient integration into policy, management and legislation. There is no national plan linking together national, regional and, to some extent, local water resource management goals and needs.

There is a strong need to compile knowledge/data/statistics on the natural water balance at catchment area level, as well as on societal water use that affects the water balance. We have insufficient knowledge about water abstractions, but better knowledge about where and how much water is discharged. The lack of knowledge also applies to the impact on water quality, not least from fugitive discharges, where we have limited knowledge about the input of substances at a level that warrants action.

The dialogue highlighted the issue of who should own the water resource and have responsibility for its management. In Sweden, unlike many other countries where water is a public utility, the water resource does not have economic value on its own, but is private property that can be used in accordance with the administrative authorisations issued. Could economic value help to ensure availability and good water quality, as well as contribute to sustainable use?

The dialogue noted that legislation needs to be developed to support sustainable water resource management in order to reduce the risks of flood and drought. All types of major water operations need permits and modern environmental conditions.

Changes in legislation, the facility to pay encroachment compensation to landowners, and a structured cooperation process at catchment area level are needed. Sustainable water resource management involves trade-offs in how water is used, which necessitates active stakeholder involvement in order to strengthen the knowledge of the natural resource and the ways in which it can be used.

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15) SGI 2020, Climate and vulnerability analysis, in accordance with Ordinance 2018:1428 on Climate Adaptation Work on the Part of Government Agencies

Definition of sustainable water resource management

The global Sustainable Development Goals (SDGs) and the EU Water Framework Directive, backed up by international research, lead to a definition of sustainable water resource management – management that meets society's current and future water needs without jeopardising nature's current and future water needs.

Since the conditions for sustainable water resource management are undergoing constant change, the management is best described as a dynamic process rather than as a state. A process in which the accumulated changes in the management lead to a gradual and clear increase in sustainability in one or more of the three dimensions of the concept of sustainability (social, economic and environmental) without direct deterioration in any of the dimensions. Adaptive management with a clear and concrete focus on sustainability.

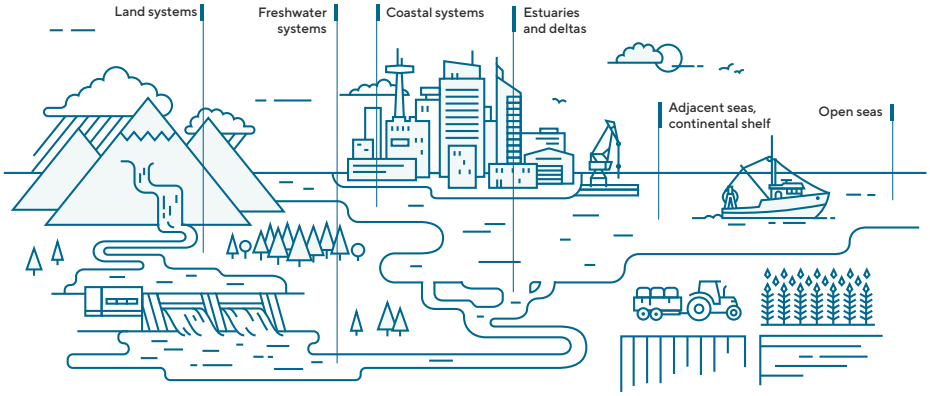

Figure. Water is of concern to many people and is an essential part of the landscape. How we manage our lakes and watercourses also affects our coastal waters and surrounding seas.

Photo: Pontus Nilsson

Proposed strategy for sustainable water resource management

The challenges posed by social change and climate change demand sustainable water resource management. An experience-based and knowledge-based management by catchment area of the entire water resource in a way that is of benefit to both the environment and society, now and in the future. The management must ensure that the overall water needs of society are met while maintaining or improving the condition of the water resource ecologically, environmentally and hydrologically.

The global Sustainable Development Goals, EU environmental regulations and Swedish environmental legislation aim to achieve sustainable water resource management – management that meets society's current and future water needs without jeopardising nature's current and future water needs. The EU Water Framework Directive also provides opportunities in this respect but has not been fully integrated into the Swedish implementation.

The assessment of the Swedish Agency for Marine and Water Management is that existing water management needs to be developed and strengthened through an increased focus on water as a resource and on the combined water needs of society and nature. Both the quality and quantity of water resources need to be considered. This involves requirements for catchment area management, participation and collaboration, long-term preventive planning, strengthened governance, predictable regulations, systematic knowledge building and designated funding. To meet these challenges, SwAM has drawn up twelve recommendations that essentially constitute a proposed strategy to develop water management into sustainable water resource management.

The recommendations show the need to raise the water issue to the level of a central societal issue and, as such, it needs to be characterised by clear governance, coordination, collaboration, a long-term perspective and sustainable solutions. Among other things, this requires:

- A clear, explicit and up-to-date target vision based on a coherent policy that covers the three dimensions of sustainability.
- Management at catchment area level that takes into account both the water resource and land use.
- Climate adaptation and reduced climate impact as an integral part of water resource management.
- That laws and regulations are coherent and promote the sustainable use of water resources.
- A developed blue-green infrastructure planning.

1. In order to contribute to sustainable social development, management must take into account both quality and quantity

The management of our water resources needs to be developed so that quality and quantity are managed in a context. Quality and quantity are inseparable concepts from a utility perspective. Water management must not only protect and strengthen ecosystems and ecosystem services but must also contribute to economic and social development.

2. The management needs to be based on the combined needs of nature and society

Access to water is crucial for nature as well as for society overall. The Management of the water resource needs to take into account the three dimensions of the concept of sustainability. This means the need to achieve a balance between different goals, needs and interests, while ensuring basic functions. A so-called nexus perspective on the water resource shows how it is used for the basic needs of ecosystems, but also for energy, industry, households, as well as green industries.
This means preserving the water resource's biodiversity, as well as essential ecosystems and ecosystem functions.

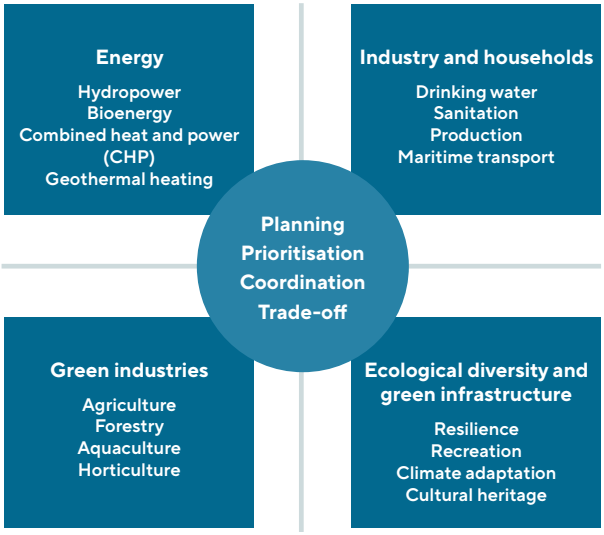

Figure. Interdependencies exist between the water resource and different sectors of society. Sustainable water resource management focuses on solutions within the sphere that contains overlapping interests, a so-called nexus. [16].

3. Clear target vision and prioritisation

To achieve sustainable water resource management requires a clear target vision, clear prioritisation and adaptive ways of working from national to regional and local levels. This is not conveyed by current water management with its diversity of water bodies, environmental quality standards and quality factors. Water is used by many people for differing purposes. Goals and claims need to be balanced against each other, which often results in a need to compromise between environmental, economic and social needs. Nationally balanced target visions and priorities need to be broken down to regional and local levels.

4. A coherent policy is a prerequisite for sustainable water resource management

Water resource policy is linked to, and dependent on, many other policy areas besides environmental policy, and vice versa. Water resource policy needs to be coordinated with other policy areas in order to combine the work on ecological, social and economic sustainability. Political participation and presence are required due to the need to manage goals, trade-offs, conflicts of interest and contradictions.

16) Based on Söderbaum & Granit 2014, the Political Economy of Regionalism 2014, developed from Phillips, et.al. (2008).

5. A developed regulatory framework

Laws and regulations need to be consistent and promote the sustainable use of water resources. In so far as possible, the regulatory framework needs to be simplified and designed with the aim of increasing legal predictability. The legislation needs to support sustainable water resource management at catchment area level. Using aquatic environments as recipients for various discharges limits the scope for other actors to use the same resource. Measures to prevent water scarcity as well as flooding often require the use of land upstream. Those affected by the measures are therefore not the beneficiaries of their effects. This requires some form of regulation and balancing. Permits for water operations are usually not limited in time and it can be difficult to evaluate the conditions for reassessment. There needs to be an improvement in both the assessment and reassessment processes and the supervision of water operations. The right to divert water may need to be balanced against obligations to retain water in the landscape, which may require a review of the Environmental Code's rules on the right to land drainage and land drainage companies.

6. Organisation and responsibilities need to be coordinated

National planning, regulation and implementation need to be kept together within one organisation for an integrated management of the water resource. The current fragmented and dispersed organisation and ways of working lead to competition rather than coordination, to the detriment of management and efficiency. This means that the management is not adaptive to new conditions, new needs, risk reduction and climate adaptation. The management must take into account both the ways in which society uses the water resource and the needs of the ecosystems.

7. Management and governance need to be based on predictability, participation, transparency and responsibility and accountability

Well-functioning and established administration and governance are prerequisites for sustainable water resource management. Understanding and trust among stakeholders, as well as knowledge and insight, are required in order to facilitate decision-making processes and trade-offs. This can only be achieved through dialogue, participation and transparency throughout the management process. The dialogue needs to be supported by legislation that allocates responsibilities, costs and compensation between those vulnerable to, for example, flooding or water scarcity and those who need to take action. Measures are often required upstream in a catchment area in order to reduce risks downstream, meaning that measures need to be taken by others than the beneficiaries of these measures. The same principle should also apply to water quality where dialogue is important and where legislation should provide support to management, governance and responsibility.

8. Blue-green infrastructure and nature-based solutions, important for society's climate adaptation

Green-blue infrastructure consists of coherent networks of natural and semi-natural water and land areas that are designed, used and managed in such a way as to preserve and strengthen biodiversity and socially important ecosystem services in the countryside as well as in urban environments. Green-blue infrastructure can, for example, include natural wetlands but also constructed rain beds, stormwater ponds, parks and green roofs that are needed to manage the effects of a changing climate. Nature-based solutions are measures based on the ability of nature to solve societal challenges. By implementing blue-green infrastructure and nature-based solutions instead of traditional solutions, we can maintain and strengthen the ecosystems and the ecosystem services provided by freshwater resources, while increasing society's resilience to climate change[17]. The implementation of green-blue infrastructure needs to be given a central role in spatial planning.

17) Nature-based solutions to 21st Century Challenges, Brears R.C., 2021

Figure. Ecosystem services in water, example from The Rich Wetlands of Kristianstad/Water Kingdom.

9. A catchment area perspective is needed

Lakes, groundwater and watercourses within a catchment area are more or less interconnected. The conditions in the aquatic environment are determined by everything that takes place within a catchment area in the form of discharges, land use, water abstraction and other impacts. Catchment areas therefore need to be the basis for sustainable water resource management as well as for decisions on what to do in order to address water quality and quantity issues. The catchment area perspective needs to be based on national strategies and decisions.

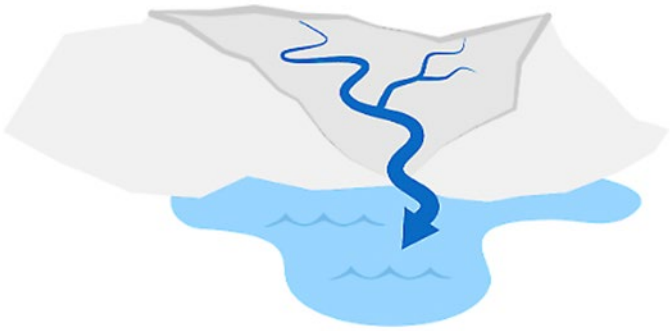

Figure. Catchment area, an area from which water drains to a watercourse upstream of a given point. The catchment area is bounded by ridges. Source: SMHI

10. Preventive spatial planning is needed

Long-term spatial planning with a landscape perspective and a coordinated management of water and land at catchment area level are needed in order to ensure sustainable water resource management and to reduce the risks associated with climate change and other societal changes. Such planning needs to be based on national and regional needs and priorities as well as local conditions. In addition to reducing risks, long-term preventive spatial planning can also contribute to strengthening the green-blue infrastructure and is therefore an important part of sustainable water resource management.[18]

18) Framework for national planning, Swedish National Board of Housing, Building and Planning, Report 2022:05.

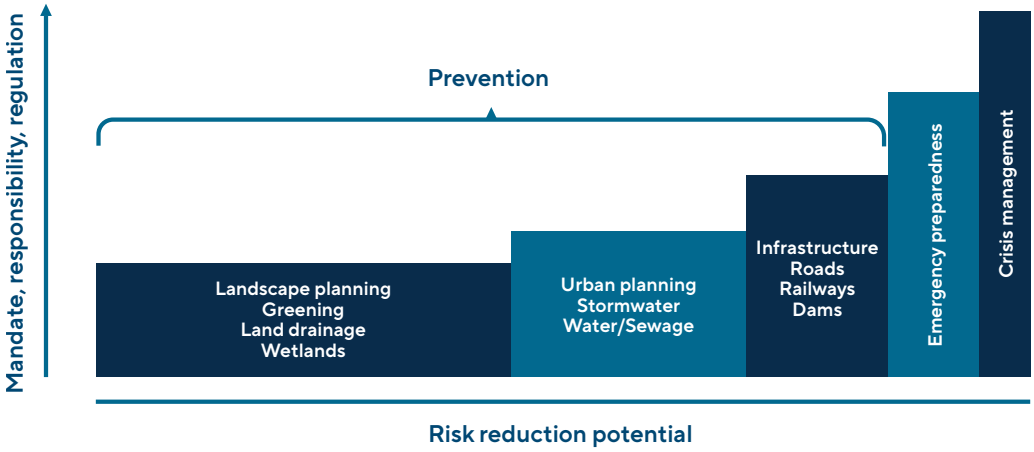

Figure. From all perspectives, preventing the risks associated with too much and too little water is a better alternative than crisis management[19].

11. Financial resources are needed

The implementation of sustainable water resource management requires financial resources in order to take the measures and make the investments needed to ensure society's access to water and to help reduce the negative impacts of climate change. This may be a question of water supply, energy supply, restoration of natural environments and climate adaptation measures in order to ensure long-term sustainable water resource management for society.

The costs of measures are usually borne by others than those who caused the problems or those who benefit from the measures. Measures also need to be implemented to prevent and reduce the risks of future flooding, water scarcity and water stress (scarcity of water of the right quality). There is therefore no clear relationship of responsibility between measures taken and benefits. There is therefore a need for some form of joint financing. Either through tax revenue or through some form of charging system that contributes both to sustainable water resource management and to financing the measures. Decisions on measures need to be based on cost-benefit analyses. In general, it can be said that flood control measures are often considered profitable, at least in urban agglomerations, and that nature-based solutions are the most profitable over time.

12. More efficient water use

More efficient water use means not using more water than necessary, using water of a certain quality where it provides most benefit, and re-using water where possible. This saves not only water but also energy and other costs related to water infrastructure. Efficient use is achieved through good management. At the landscape level, good management can mean, for example, planning multi-purpose wetlands, while for an operator it can mean savings, more efficient processes, leakage reduction measures or use/re-use of water of different qualities. Different policy instruments are needed in order to improve efficiency on a larger scale.

19) Based on the idea of WMO/GWP, 2018 and Aspegren et al. 2019

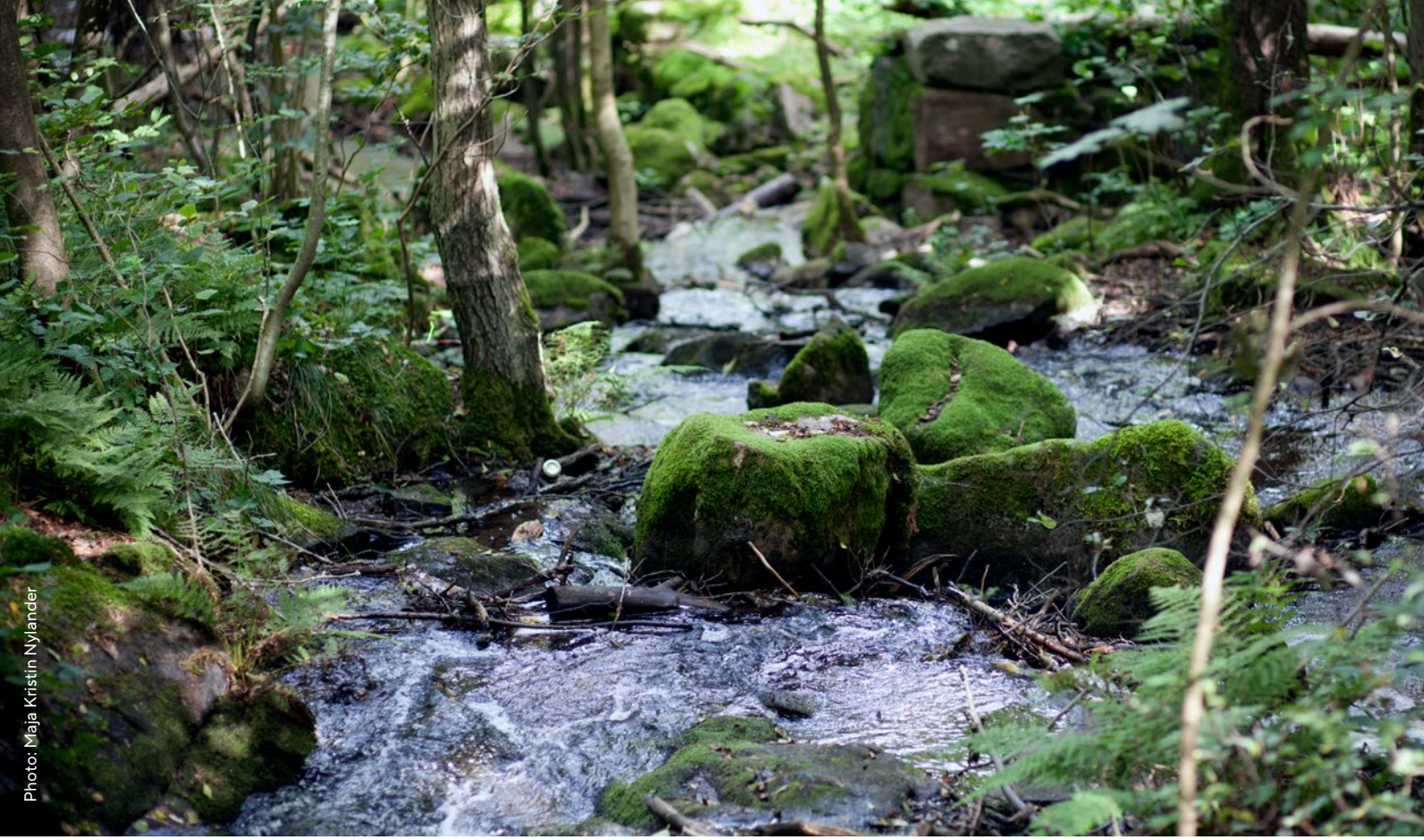

Photo: Maja Kristin Nylander

Sweden's freshwater resources

Sweden has very favourable physical water characteristics with good availability of groundwater, lakes and watercourses. Water resources and water flows are largely determined by precipitation, which means that water availability varies throughout the year and between years. Periods of wet, hot and dry conditions can therefore result in rapid changes and significantly unfavourable conditions for "normal" water use. At the local level, for limited periods, water availability may not cover all needs and water scarcity may occur.

Sweden has a good supply of both surface and groundwater

Sweden is one of the most lake-filled countries in the world, with 9 per cent of the country's surface area consisting of inland water, i.e. just over 40 000 square kilometres. There are 100 000 lakes larger than one hectare and another 250 000 smaller water bodies. Surface water resources amount to 500 cubic kilometres, of which Vänern accounts for almost a third.

Groundwater can be found everywhere, but the geological conditions limit how much there is and how accessible it is in different locations. Major groundwater resources can primarily be found in large glacial river deposits in the form of pebble ridges, but can also be found in some areas with sedimentary bedrock, such as the Kristianstad plain[20]. For municipal drinking water supply, large groundwater reservoirs are normally used from which large long-term water abstractions can be made through a small number of wells. Small groundwater reservoirs are important for individual drinking water supplies.

20) Sweden's groundwater resources – importance for business development and growth, SGU 2009

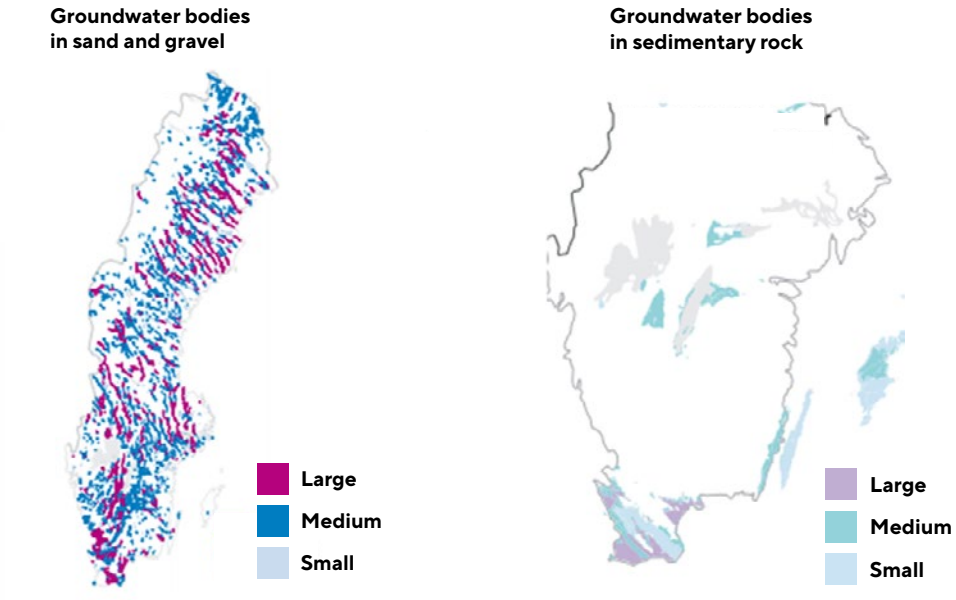

Figure. Groundwater occurs in rock and soil layers throughout Sweden, but the most accessible volumes of water can mainly be found in the superficial sand and gravel deposits (left image) and in the porous sedimentary bedrock (right image). Source: SGU

Water balance and water availability

Water balance describes the amount of water entering and leaving an area. Water balance in a catchment area means that precipitation over the area is either stored temporarily, evaporates or runs off. The water balance equation represents the difference between total precipitation and the water that evaporates, is absorbed by vegetation, is removed by water abstraction, runs off to the sea, or is stored in lakes and groundwater reservoirs.

The water balance equation

Runoff = Precipitation – Evaporation and plant transpiration – Change in storage (in snow, lakes, soil water and groundwater).

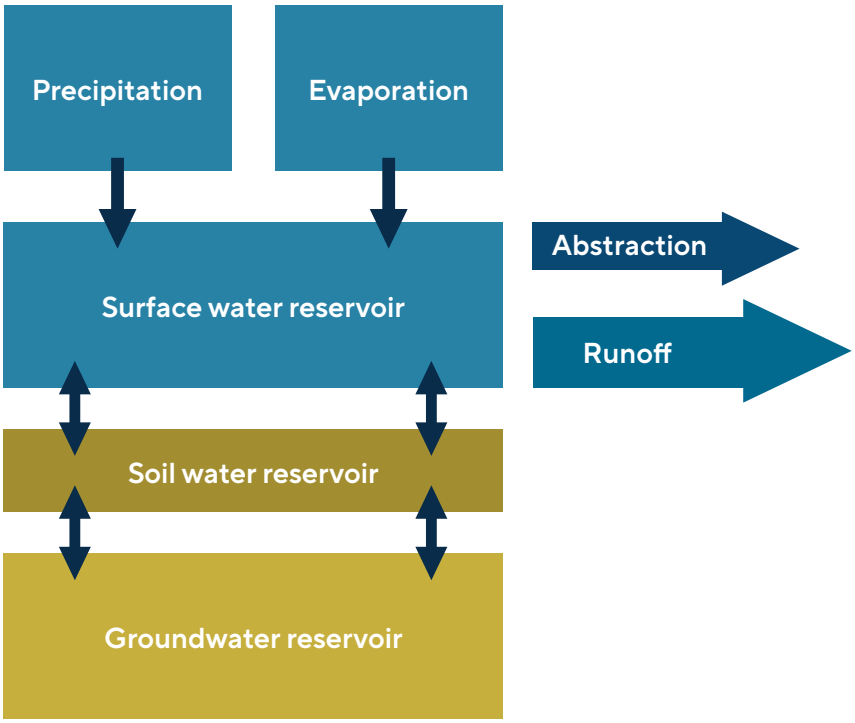

Figure. Schematic diagram of the water balance. Water arrives in the form of precipitation and is lost by evaporation or absorbed by vegetation, runs off into the sea or is stored in snow, lakes, soil or watercourses.

Annual precipitation generally varies in Sweden between 500 and 800 millimetres per year. The precipitation that falls over land runs off via the soil and groundwater into lakes and watercourses on its way to the sea again. Surface water primarily originates from groundwater outflow. The western parts of Sweden generally have the most precipitation. Runoff varies from season to season and the variation is different in different parts of the country. Seasonal variation is largely due to storage of precipitation in the form of snow, as well as storage such as soil and groundwater. Storage in lakes and watercourses has a levelling effect on the course of the flow of rivers and streams.

Accordingly, the water balance varies between years, seasons and regions. Only a few per cent is abstracted for use in different industries, but can still cause low water levels and flows during droughts. In a government commission, SMHI has investigated and established that there is a great need to increase knowledge about water abstractions, especially in vulnerable areas in south-eastern Sweden. This is necessary in the climate adaptation efforts and for planning the use of water resources[21].

21) SMHI 2020. Increased knowledge of water abstraction in Sweden, Hydrology 126

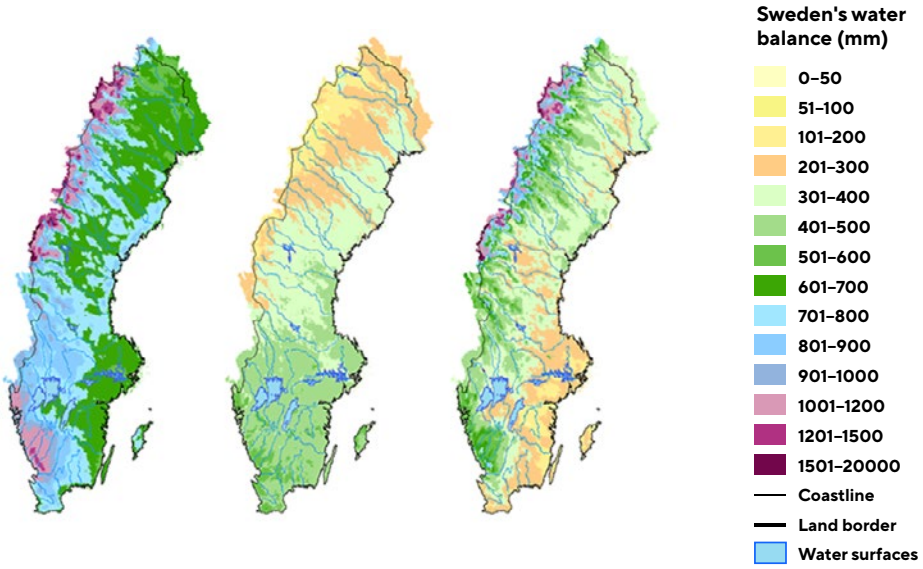

Figure. Sweden's water balance for the period 1981-2010. The maps show from left: modelled values for annual precipitation, annual evaporation and annual runoff in mm. Source: SMHI.

Runoff

Runoff is the part of the water balance available for the needs of people and aquatic environments after the land ecosystems have had their needs met. Runoff in a watercourse is the total amount of water flowing out of the watercourse's catchment area during a given time interval.

Surface runoff is the part of the precipitation that flows directly on the surface of the ground into a watercourse. In Sweden, surface runoff is often small, especially during the growing season when most of the water is absorbed by the soil and plants.

In northernmost Sweden, annual runoff is dominated by water from snowmelt since much of the annual precipitation falls as snow. In the mountains, the spring flood occurs in June and July, while for the forest rivers, the spring flood comes as early as May. High flows occur in summer and autumn due to rainfall.

The specific runoff, i.e. the runoff per unit area, is a measure of the long-term water availability in the area, and it is often expressed in millimetres. In general, the specific runoff is highest in the mountain range and along the west coast and is lowest in south-eastern Sweden, including Öland and Gotland.

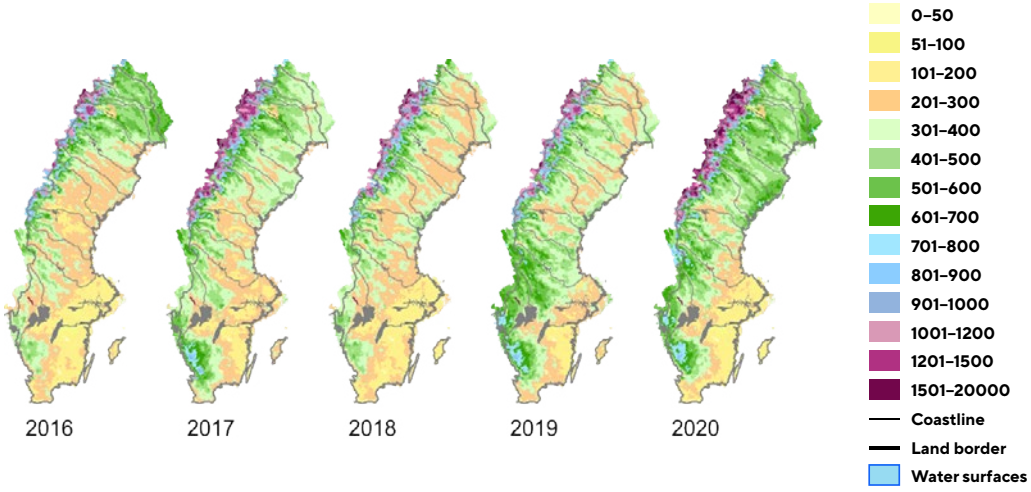

Figure. Annual specific runoff 2016 to 2020. Source: SMHI[22]

Ecological flow is the proportion of the natural water flow that needs to be ensured in the watercourse in order not to risk negative ecological consequences. The ecological flow varies depending on the shape of the watercourse and the composition and complexity of the ecosystem. A rule of thumb can be that the flow is not less than 30 per cent of the mean annual flow. In a flow of less than 10 per cent of the mean annual flow during the summer season, harmful effects have been observed in fish and aquatic plants[23].

Main catchment areas and administrative divisions

Sweden's watercourses are divided into a number of main catchment areas. These were defined in 1908 by SMHI as a watercourse with a catchment area at its mouth with the sea of at least 200 km2. The catchment area is bounded by a watershed. The watershed is usually an elevation where the water flows on either side of the elevation into different catchment areas. The division into main catchment areas starts in the far north with the Torne River (No. 1), and follows the Baltic Sea coast southwards to be numbered northwards on the west coast, and then ends with the Enningdal River, which flows into Idefjord on the border between Sweden and Norway (No. 112). In addition, there are some main catchment areas draining from Sweden to Norway (No. 113 – 116), the main catchment areas of Gotland (No. 117 – 118), and the whole of Öland (No. 119). There are so-called coastal areas, normally smaller than 200 km2, located between the main catchment areas.

The administrative division into counties, regions and municipalities does not follow the hydro-geographical division. The counties of Norrbotten and Västerbotten include the majority of several main catchment areas, while other counties normally share the main catchment areas and coastal areas to varying degrees. Many municipalities are also affected by several main catchment areas and coastal areas.

Despite most of the main catchment areas being located within Sweden's borders, the border river with Finland, the Torne River, is a clear exception, and the countries have therefore signed a special border river agreement for collaboration and cooperation. There has also been a border co-operation agreement since 1929 for the cross-border main catchment areas between Sweden and Norway, in which the largest cooperation areas are the Enningdal River and Klarälven-Trysilelva.

With the advent of the Water Act in 1918, water courts were also introduced whose territorial jurisdiction followed the main catchment areas. The current division of the five land and environment courts also primarily follows the main catchment areas for their territorial jurisdiction.

Five water districts were introduced for the implementation of the EU Water Framework Directive. These districts were primarily based on the sea basins into which the main catchment areas flow. For each water district, the county administrative board, in its role as the water authority, must draw up specified plans and programmes in cooperation with the county administrative boards affected and in collaboration with other parties. The water districts and the territorial jurisdiction of the Land and Environment Court are essentially the same areas, but differ in some main catchment areas.

22) https://vattenwebb.smhi.se/avrinningskartor/

23) Environmental effects of water abstraction in surface waters, www.havochvatten.se, 2017

Figure. Main catchment areas in Sweden (SMHI)

Figure. Sweden is divided into five water districts that are primarily based on the sea basin into which the main catchment areas flow. The division results from the administrative implementation of the EU Water Framework Directive. Five county administrative boards have been appointed as regional water authorities and draw up plans and programmes for the areas. Source: County Administrative Board.

How much water can be abstracted?

For surface water, the potential for abstraction depends on the river discharge (flow), the size of the catchment area, the proportion of lakes in the area, and how periods of low flow affect the surface water. During the summer months, when water demand is often highest, water availability is usually lowest. This is why water scarcity most often occurs during this period. When the water flow in the watercourses is at its lowest, this may mean that water abstractions in some watercourses have a major impact on the water flows. One example is the Emån River, which would literally run out of water during the summer months if all of the water abstraction permits granted were fully utilised. Now this does not happen, partly because the permits are not fully utilised, and partly because there are technical limits on water abstraction amounts[24].

Groundwater formation

For large groundwater reservoirs, the annual groundwater formation is generally decisive for how much water can be abstracted. Groundwater formation is the process that leads to the replenishment of our groundwater reservoirs. The most important factors for groundwater formation are mainly the amount of precipitation and the extent of evaporation. Relatively little groundwater is formed during the growing season due to the uptake of water by vegetation and evaporation. The length of the growing season varies from just over 100 days in the north to just over 200 days in the south[25].

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24) Model study to investigate measures that affect low flows – Interim report 2 in the government commission on measures to counteract water scarcity in surface water supply points. SMHI Hydrology 121, 2019

25) Groundwater formation and groundwater availability in Sweden, SGU, 2017

Gotland's drinking water supply

Gotland has recurring problems with the supply of drinking water in connection with the temporary population increase during the summer months and the associated high water consumption. The shortage is mainly caused by the fact that the groundwater reservoirs in the soil layers and bedrock on Gotland are small or barely known. Thin soil layers and relatively dense bedrock mean that the majority of the precipitation that falls in autumn and spring does not form groundwater but runs off from the surface of the ground.

Moreover, groundwater formation during the summer period is very low due to a small amount of precipitation, the uptake of water by vegetation and evaporation. In addition to the lack of groundwater reservoirs, the groundwater supply points on Gotland often contain salty groundwater.

To ensure access to water, the county administrative board, in cooperation with Region Gotland and LRF, has drawn up a regional water supply plan for Gotland that runs up to 2045[26].

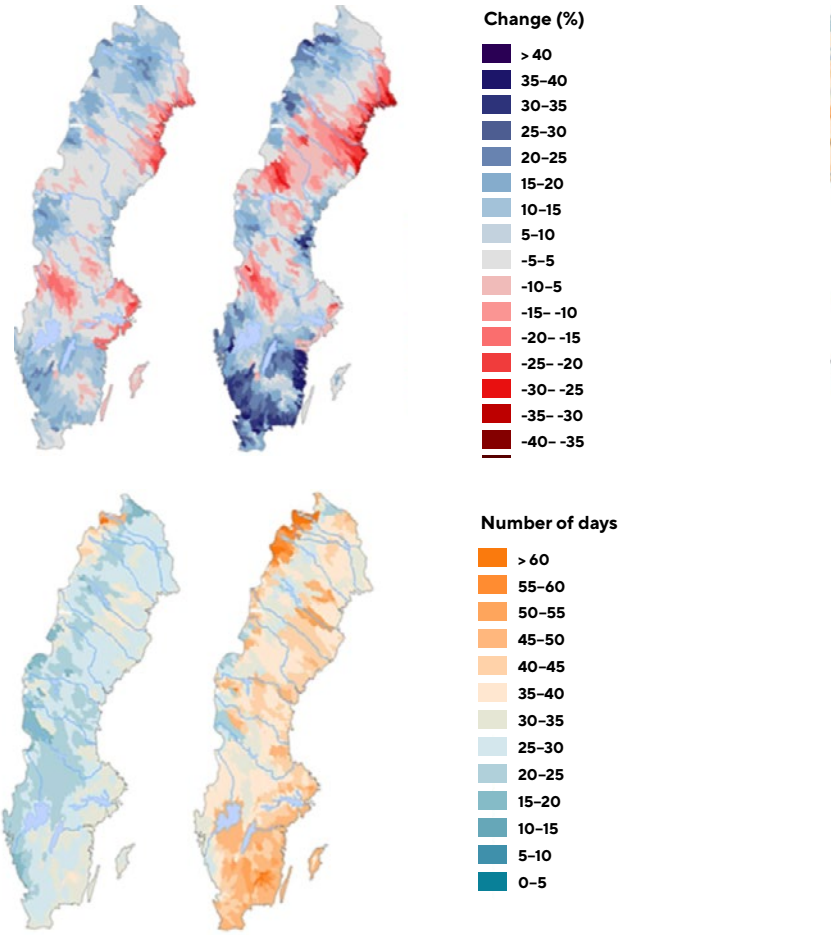

Figure. The maps show how 100-year flows and dry periods will change based on two different climate scenarios. Source: SMHI

26) Regional water supply plan for Gotland County. County Administrative Board of Gotland County. 2018

Climate change increases the risk of flooding and water scarcity

Climate change is making Sweden warmer. Even if average precipitation does increase, a higher temperature will lead to increased evaporation. The growing season will be extended, which means a reduction in periods of groundwater formation since plants absorb the water in the soil and it does not run off into the groundwater. During parts of the year, Sweden will experience longer dry periods, in particular in the south east, which may result in reduced water availability and water scarcity. When rainfall is below normal, the soil water, lakes and watercourses are not replenished as usual.

These changes will also lead to increased frequency of flooding of lakes, watercourses and coastlines due to increased precipitation and the rise in sea level. In addition, the frequency and intensity of torrential rainfall will increase, which may cause localised flooding.

Milder winters also change the conditions for snow, which will affect the watercourses in northern Sweden in particular. The runoff is projected to increase for Sweden overall, by between 5 and 25 per cent, but with large regional differences. The largest increase is expected to be in the mountain region, while the south-eastern parts of the country may see a reduction in water availability. The spring flood is likely to be weakened, taking place a few weeks earlier than today and then to disappear completely in the south of the country[27].

Susceptibility to drought and risk of water scarcity

Susceptibility to drought in Sweden varies. Key factors include climate (precipitation and temperature), water use and reservoir capacity. Weighing these factors together gives a picture of water scarcity. SMHI and SGU continuously compile information on the risk of water scarcity.[28].

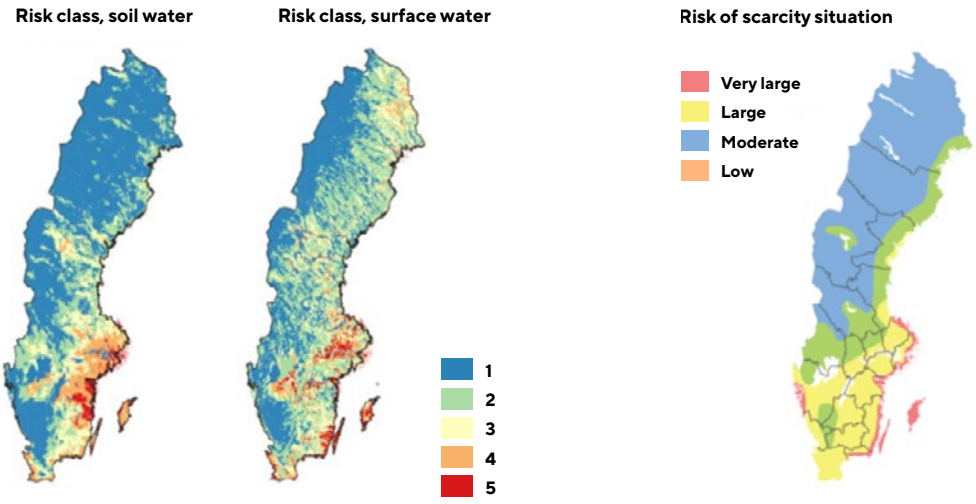

Figure. The map on the left and in the centre shows areas that are rarely (1) or relatively often (5) affected by soil or surface water scarcity.[29]. The map to the right shows areas where there is a risk of water scarcity in groundwater[30].

27) www.smhi.se

28) Risk of water scarcity | SMHI

29) HYDROLOGY No 120, 2019 Sweden's water supply from the perspective of water scarcity and drought – Interim report 1 in the government commission on measures to counteract water scarcity in surface water supply points.

30) Final report of government commission, Groundwater initiative 2018–2020 (sgu.se)

Storage takes place as snow/ice, soil water, groundwater and surface water. Storage means that water flows in brooks, rivers and streams even when it is not raining. Storage capacity varies in time and space. Surface water storage capacity reflects the existence of large lakes and power plant reservoirs. Storage capacity is low on Gotland and Öland and on the agricultural plains of southern Sweden.

Susceptibility to flooding

Flooding is usually caused by heavy precipitation, large amounts of meltwater over long periods, or by intense torrential rainfall. Torrential rainfall is usually most significant in urban areas where flooding is caused by water not having the opportunity to drain away quickly enough. Heavy precipitation or large amounts of meltwater increase water levels in lakes and watercourses, which can cause flooding. The spring flood is a common cause of flooding, especially in northern Sweden.

In southern parts of the country, flooding can occur throughout the year due to periodic heavy precipitation. During short but intense rainfall, small watercourses and lakes are mainly affected, while prolonged continuous precipitation has most impact on large watercourses. Flooding caused by periods of heavy precipitation and/or large amounts of meltwater is expected to become more frequent and severe, particularly in southern Sweden and in the mountains. Torrential rainfall is also expected to become more frequent and intensive, but there are no clear geographical differences.

Urbanisation and reclamation change the water balance

Since the soil in cities and towns is largely sealed, it is less able to absorb and infiltrate rainwater. This becomes clear during torrential or prolonged rainfall when large amounts of water have to be delayed and infiltrated locally. The water flows into in rainwater run-off and wastewater pipes that are not designed for large volumes of water. This can lead to flooding and the spread of pollutants. Sealed surfaces also change the availability of water in the soil and consequently affect the ecosystems. Our reclaimed landscape also contributes negatively to the deterioration of the storage capacity for water of the landscape.

Photo: Jon Flobrant

Nature's needs

In the context of water resources, nature is the water-dependent part of the biosphere, i.e. the sum of all water-dependent ecosystems in the hydrosphere and lithosphere. Nature's ecosystems provide various benefits to people, known as ecosystem services.

Ecosystem services

The concept of ecosystem services was introduced in the 1980s in order to estimate the value of the benefits provided to us by nature. Ecosystem services are usually divided into four categories: supporting, regulating, provisioning and cultural. Nature's needs can be described by the supporting ecosystem services.

The supporting ecosystem services provide the basic functions of the ecosystem, which means that they are a prerequisite behind the existence and functioning of the other ecosystem services.

The regulating ecosystem services reduce different types of environmental problems and include, for example, ways in which nature can deal with pollutants and flooding.

The provisioning ecosystem services are the goods and products provided to people by ecosystems, such as different types of food and water use in the form of drinking water and irrigation.

The cultural ecosystem services include experience-based services that are important for emotional well-being, such as aesthetic values and recreational values. These form an important part of people's culture and have been shown to have beneficial effects for health.

Ecosystems and biodiversity

Lakes, watercourses and groundwater provide many benefits to society. Such ecosystem services provide drinking water, food and water for agriculture, which create the conditions for our welfare and development. Prerequisites for ecosystem services include functioning ecosystems and the preservation of biodiversity at different scales[31], which in turn require long-term sustainable management of natural resources.

Biodiversity in and within a catchment area is dependent on the size of the area, local factors, such as altitude and surrounding soil conditions, as well as the structure of the water landscape and the connectivity (opportunity to connect between different habitats and species) along and beside the water system[32].

Freshwater ecosystems are dependent on a range of conditions such as water turnover, stratification, temperature, light, chloride content, organic matter, acidity, nutrients, oxygen and hydromorphology. Freshwater ecosystems are highly stressed due to extensive impacts over a very long period of time. In order to provide a growing population with food, energy and materials, work has been in progress for a couple of hundred years on damming, regulating, channelling, clearing and straightening rivers, lowering lakes and draining wetlands. This work has had a major impact on biodiversity, ecosystems and the ability of organisms to move through the water landscape.

The physical impact has greatly affected the habitat of species in watercourses throughout the country. A large proportion of rapids have disappeared due to damming. The estimated number of dams we have in Sweden is around 10 000. The ability of species to move around in waterways and the transport of sediment and nutrients has been severely limited by various man-made barriers. Clearing and straightening for log driving and land drainage has had a major impact. Physical impact and disturbed flow regimes due to regulation are the main reason for not achieving good ecological status according to the Water Administration Regulation[33].

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31) Ecosystem services from Swedish lakes and rivers, the Swedish Agency for Marine and Water Management, Report no. 2017:7.

32) River network properties shape a-diversity and community similarity patterns of aquatic insect communities across major drainage basins, Altermatt et al, J. Biogeogr.v 40, 2013

33) The impact of hydropower on aquatic ecosystems, the Swedish Agency for Marine and Water Management, Report no. 2013:10, 2013

In order to facilitate food production in the agricultural areas of southern Sweden, three quarters of the surface water area has disappeared over the last 200 years[32]. The habitats of organisms are changed by the effects on temperature, bottom characteristics and sediment transport. Water availability in lakes and watercourses is also affected by water abstraction for various activities, which reduces the amount of water in the landscape and has the potential to affect habitats as well as the opportunities for organisms to move, and thus their ability to live and reproduce.

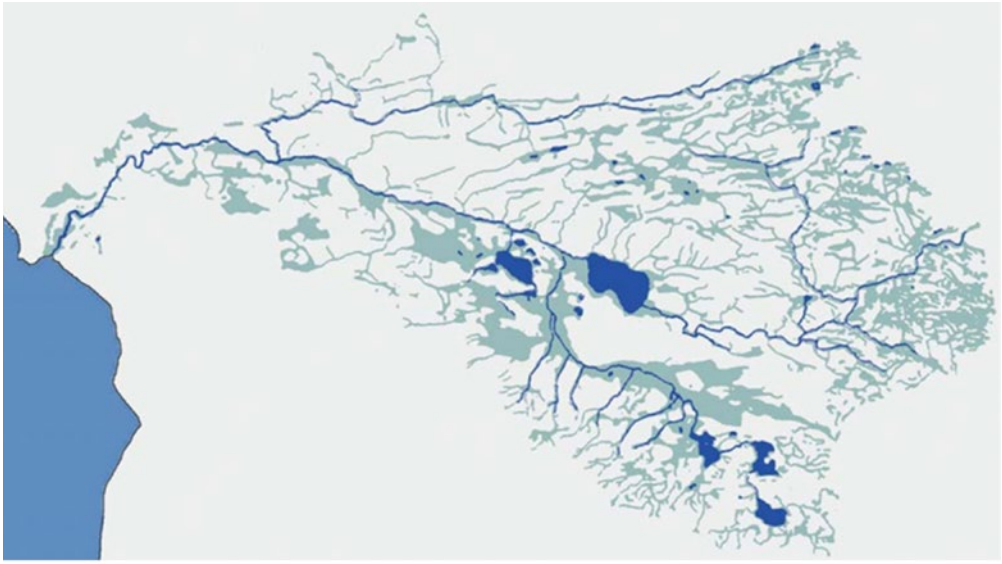

Figure. Kävlinge River's catchment area, the green-blue areas show water in the landscape around 1820. The dark blue areas show the situation in 1959 when only 12 per cent of the landscape's original water surface remained[34].

Climate change means that flooding along lakes and watercourses will become more frequent. This will have an impact on the ecosystems and ecosystem services affected[35]. Flooding can affect both water quality and biodiversity through increased leakage of nutrients, wastewater and pollutants. Increased water temperature can adversely affect many species and encourage the growth of algae and cyanobacteria, which can contribute to oxygen deficiency in lakes and an increased frequency of toxic blooms. Climate change also affects species composition.

34) Water and biodiversity in the agricultural landscape, Feuerbach, P. Strand, J. 2010.

35) What happens in a future climate with catchment ecosystem services? Sara Bergek and Leonard Sandin, SLU Aqua reports 2021:2, 2021

Photo: George Sultan

Water use

All sectors use and have an effect and depend on water

Our water resources are used for energy production, green industries, drinking water supply, industry and ecosystems. Lakes and watercourses are also used for shipping, fishing and recreation, such as swimming and boating. The use of water affects the basic functions of the ecosystems. To identify how different sectors use and impact on the water resource is a fundamental requirement in the implementation of the Water Administration Regulation and the Water Framework Directive and is an important basis for establishing standards and for developing proposals for measures.

A look back

Access to freshwater has been crucial to Sweden's development, particularly during industrialisation. Flowing and falling water has been used as a source of power for grinding flour and processing wood and ore for hundreds of years. The oldest evidence of flour grinding mills in Sweden dates from 1185 (Medieval Sweden 1:4 Tiundaland). At the end of the 1800s, hydropower was given a major boost from inventions such as the electric motor and the electric generator.

By today's standards, agriculture in the 1700s was very unproductive. The transformation of agriculture and agricultural society during the 1700s and 1800s centuries is usually summarised by the term "agrarian revolution". The landscape was transformed by new cultivation and reclamation, mainly in the 1800s, creating the main features of today's agricultural landscape, which has resulted in the disappearance of 70-90 per cent of the visible water in the agricultural landscape, among other things. However, the development of agriculture contributed to strong population and economic growth, which are considered to have been prerequisites for industrialisation. (History of Swedish agriculture).

Forestry has also affected and continues to have an effect on water. The existence of forests affects evaporation. At the outset of the 1900s, the growing stock in Swedish forests was assumed to be at a minimum. This resulted in demands for replanting. Since 1923, at the start of the national forest inventory, the growing stock has doubled. Forest drainage gathered pace in the 1870s and almost completely stopped in the 1940s. The reasons behind drainage have varied over time and included frost damage, paludification, growth and production (when forest drainage was an issue that divided Forest Sweden).

Flowing water has been used as a source of power for a very long time. The first known water mills in Sweden are from the 11 to 1200s. The mills were used, for example, for saws, mines and blast furnaces. The advent of the water turbine and electrification in the late 1800s marked the start of an extensive expansion of hydropower, which was of great importance to Sweden's industrialisation and growth. Approximately 85 per cent of Sweden's watercourses have been used, which has had a major impact on the ecology and biodiversity of lakes and watercourses.

The overall development has resulted in a drastically changed landscape where many natural lakes and wetlands have been drained and reclaimed to create new arable land or improve forest growth. In some parts of Sweden, as much as 90 per cent of natural wetlands have been drained and disappeared[36].

Many other activities have affected the water systems in different parts of the country, such as log driving, canals, mining, industrialisation, urbanisation with water management and wastewater disposal, hydropower, etc.

Water abstraction involves the drainage of water for use in industrial activities, drinking water production or agricultural irrigation. Water abstraction and water use in Sweden is reported by SCB every five years, broken down by the categories of households, manufacturing industry, agriculture and other users. The statistics are broken down by water district and county level. Industry's water abstractions are produced using a questionnaire survey, usage and municipal water supply use Swedish Water (VASS) data, and agricultural abstractions use standardised calculations.

Manufacturing industry accounts for the majority of water abstractions

Water use and the distribution between different purposes vary within the country. The total use of freshwater in Sweden in 2015 amounted to approximately 2 400 million cubic metres. The abstractions are equivalent to just over one per cent of total precipitation. Manufacturing industry uses the most water (61 per cent), followed by households (23 per cent), other water uses (13 per cent) and agriculture (3 per cent). Water use has generally decreased slightly since 1990. The decrease has taken place in both industry and in households.

Most of the freshwater abstracted in 2015, 80 per cent, was surface water from

36) Knowledge base on the ecological and water management functions of wetlands

lakes and watercourses. Surface water also includes groundwater produced by artificial infiltration. Groundwater accounted for 14 per cent. The remaining 7 per cent could not be divided between groundwater and surface water.
Industry's water consumption is dominated by heavy basic industry. The pulp, paper and paper products industry is the sector with by far the largest abstractions and water use. The manufacturing industry for chemicals and chemical products as well as steel and metal works also use large amounts of water. Together with the pulp, paper and paper products industry, water use in these sectors amounts to 80 per cent of industry's total abstraction[37].

Individual and public water supply

Individual water supply points refer to both private wells used by households and water supply for the abstraction of water for agriculture and industry. Individual water use accounts for 60 per cent of the total freshwater abstractions. The largest proportion (90 per cent) is for industrial purposes.
Public water supply is provided by municipal waterworks, primarily for domestic drinking water supply, but also for use in industry and agriculture, as well as other water uses. Approximately 86 per cent of drinking water comes from municipal waterworks. Of the more than 2000 public water supply points in Sweden, 200 are surface water supply points and the remainder are groundwater supply points[38]. In the public water supply, the water loss is approximately 20 per cent, of which leakage on the pipe network is on average approximately 15 per cent[39].

	General Millions of cubic metres	Individual Millions of cubic metres	Total Millions of cubic metres	Per cent
Households	488	77	565	23
Agriculture		75	75	3
Industry	162	1316	1478	61
Other uses	313		313	13

Table. General and individual freshwater use in Sweden 2015 by sector of society. Source: SCB's Statistical Database.

Hydropower accounts for a significant impact

Hydropower is by far the largest user of water in Sweden.[40]. Large-scale hydropower plants with high levels of electricity production are important for Sweden's overall electricity supply. At the same time, dams and hydropower plants cause other environmental problems. Many small-scale hydropower plants have a large impact on the environment in relation to the amount of electricity they produce.

For example, hydropower plants and dams can act as barriers to fish migration and cause changes in water flows and the transport of sediment. Diverting water means reducing the natural flow of water, which can reduce the size of the habitat for species. Excavation and filling means that the natural bottom environment is reduced, which can have an adverse effect on species that may be dependent on a particular bottom environment.

37) Industrial water use, 2020 Water abstraction, use and discharge in the industrial sector, SCB, 2021

38) Swedish Water Archive, SGU

39) www.svenskvatten.se

40) Increased knowledge about water abstractions. Report of government commission, Anna Eklund et al, SMHI Hydrology 126, 2020

Artificial storage of water for different needs[41]

According to SMHI's dam register, there are 11 000 dams in Sweden. Many small dams have their origins in the 1600s to 1800s, when they were built to power mills, sawmills and facilitate log driving. Today, dams are mainly used for power generation, drinking water supply and irrigation, as well as process water for industry/agriculture/artificial snow. Many of the dams are not used for any purpose at all.

There are about 2000 hydropower plants and a further one thousand dams associated with hydropower plants. Approximately 200 hydropower plants account for over 90 per cent of the annual production and the total installed capacity of Sweden's hydropower plants.

Dams affect the natural hydrology by reducing water velocity, increasing evaporation and changing the natural flow regime. The morphology (shape) of the watercourse is also adversely affected. The effects of dams include changes to the natural erosion of a watercourse and changes to the transport of nutrients, as well as the dampening of flow variations. Water temperature and water quality can also be affected.

Flowing water hosts a high diversity of habitats and species. Biodiversity is negatively affected, both upstream and downstream of dams. The largest proportion of freshwater red-listed species is associated with watercourses where migration barriers and water regulation threaten species such as trout, eels, freshwater pearl mussels and thick-shelled river mussels. Fragmentation caused by dams means that riverine populations are more affected by other stressors such as drought, increased water temperature, flooding and disease.

By removing dams and other barriers, natural hydrology and morphology can be restored in order to provide free-flowing water and maintain biodiversity and key ecosystem functions. At the same time, consideration needs to be given to the importance of dams for reduced climate impact and climate adaptation[42].

Figure. Dams in Sweden according to SMHI's dam register.

41) The Swedish Agency for Marine and Water Management's report on the government commission to compile knowledge of dams 2021.

42) Lindström, A., Granit, J. & Weinberg, J. (2012). Large-scale water storage in the water, energy and food nexus: Perspectives on benefits, risks and best practices. SIWI Paper 21. SIWI, Stockholm

Water abstraction in relation to available water resources

In Europe, Sweden belongs to the group of countries with the lowest water abstractions in relation to supply. (If hydropower had been counted as water abstraction, the proportion would have been different.) Within the group with low water abstractions, Ireland, Iceland, Latvia, Norway, Portugal and Slovakia all have water abstractions that are less than 1.5 per cent of the annual supply via precipitation and runoff. Sweden, Malta, United Kingdom, Italy, North Macedonia, Belgium, Spain, Bulgaria and Cyprus are the countries with the highest abstractions relative to supply, and all have abstractions exceeding 20 per cent of supply, a figure that represents an indicator of water scarcity. Cyprus's water abstraction is equivalent to 45 per cent of supply, which is the highest in Europe[43].

Despite the generally favourable supply of water, water scarcity also occurs in Sweden. As a rule, water scarcity is linked to the summer season when the need for water to irrigate crops is greatest, combined with high water use by a large population in the summer months. Even though Sweden has a large supply of water compared to many other countries, water is a natural resource that should be managed carefully. The production and distribution of drinking water also requires a lot of energy. Lower water consumption reduces the load on water and sewage systems, which reduces maintenance costs and investment needs. Water management is a cost-effective and environmentally friendly way to reduce the demand for water.

Water use in agricultural activities

Agriculture

Water is primarily used in Swedish agriculture for crop irrigation and animal husbandry. Of the 75 million cubic metres of water used by agriculture in 2015, around 64 per cent was used for irrigation and the remaining 36 per cent for drinking water for livestock[44]. Animal husbandry requires a continuous supply of water, approximately the same amount all year round, supplied by groundwater abstraction or surface water abstraction. Globally, agriculture is the sector of society that uses the most freshwater, at almost 70 per cent of total freshwater abstraction.

The water needs of agriculture for crops are mainly met by precipitation. A small part of the agricultural area is irrigated, primarily in highly productive areas where water availability varies in southern and south-eastern Sweden. The need for irrigation arises because evaporation during the growing season is greater than precipitation. Water for irrigation can be obtained from surface water, groundwater or drainage water. Vegetable cultivation has greater requirements for regular water supply, and most areas are irrigated.

Agriculture has a significant need to divert water from a land area, which can also be counted as water use. For good crop growth, arable land needs to be sufficiently drained to allow root systems to develop, which means that much of arable land and pasture land is therefore drained.

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43) www.eea.europa.eu

44) SCB, 2017. Water use in Sweden 2015.

According to Swedish Board of Agriculture, farmers should pay more attention to their water needs and review the conditions for water abstraction, more efficient water use, storage and emergency water supply, in particular in regions at risk of water scarcity.[45] Water abstraction for agricultural purposes accounts for only 3 per cent of total freshwater abstraction, but in some regions of southern Sweden it accounts for a significantly higher proportion in certain areas during dry summers when there may be limited water availability in lakes, watercourses and groundwater reservoirs. In some areas there is competition between the need for drinking water and agricultural irrigation water. Greater attention needs to be paid to agricultural water needs, not least because of a future climate with greater variations in precipitation between regions.

Forestry

The water needs of forestry are met by precipitation. To increase forest growth, significant areas of forest land have been drained in order to improve the development of root systems, and many wetlands have been drained for forestation.

Even though the proportion of land irrigated in agriculture and forestry is small, land drainage is very widespread in Sweden. The consequences of over 900 000 km of ditches are still not fully investigated.[46]

Future water needs?

Water use in industry fell sharply during the 1970s. From the 1980s to the present day, water use has remained at a relatively stable and has remained unchanged in recent years[47]. Many industries use large amounts of water, but there is potential for better water management due to the many incentives for industry to save water, while the potential for savings can be significant in most sectors.[48] By preventing water losses, reducing water use and reusing or recycling water, industries can promote efficient water use to prevent problems of water scarcity.

The future water needs of agriculture are difficult to assess and are affected by climate change and changes within agriculture. Regional variations can be great Taken overall, ongoing climate change not only contributes to the risk of intermittent and regional reductions in water availability. It also leads to an increase in the water needs of agriculture in the long-term. More knowledge is needed to assess future needs, especially in areas where there may be competition for water.

The future water needs of households depend on population growth, developments in water technology, as well as on the amount of water used per person. Household water consumption has declined in recent decades, with low-flush toilets and more efficient household appliances playing an important role. In 2050, the population is expected to pass 12 billion, an increase of approximately 15 per cent from 2020. It is not certain that this will result in increased water needs on a national level. Since the growth is mainly expected in the metropolitan regions and large cities, increased needs may arise on a regional basis.

45) Water supply needs of agriculture. Swedish Board of Agriculture report 2018:18.

46) SOU 2014:35. Wet and Dry – Proposal to change water-related regulations.

47) Industrial water use 2020 Water abstraction, use and discharge in the industrial sector; SCB 2021

48) When the water supply is scarce, Sjöstrand et al, RISE Report :2019:79, 2019

Photo: Jana Sabeth

Water's experience values

Water is life but also health and recreation

For us humans, water is not only vital from a biological point of view but also a resource that we benefit from on a daily basis. People have always lived with and by water. Many ancient monuments and other cultural sites are located by water as symbols of human dependence and development by water. Many of these cultural sites still constitute significant experience values in the landscape. The importance of water to people is also emphasised in literature and art, where water forms the background or central element in the works in various ways.

The attractiveness of water for our living environments is still strong. Half of Sweden's population lives within 10 kilometres of the coast and it is estimated that most people are only a few kilometres from the nearest lake, watercourse or coastal water. This is also reflected in higher property values in waterfront locations, and that more and more of the planning aspirations are to "face" the water, for housing and recreation in both urban and rural areas.

Our recreation is often drawn to aquatic environments, especially in summer. It takes place in all forms, in the water, on the water or next to the water. A picnic at sunset, a fishing trip at sunrise, swimming from cliffs or sandy beaches, paddling a canoe on mirrored water, ice skating on glassy lakes – Sweden offers endless opportunities for water experiences throughout the country. Tourists from other countries appreciate Sweden's relatively unspoilt lakes and watercourses as this is a rarity elsewhere.

Access to water is also a prerequisite for many forms of recreation and sport. Swimming, sailing and bathing are obvious examples, but that water is also a prerequisite for golf and skiing, for example, may not always be so well known. Golf courses require irrigation and ski slopes need to be primed with artificial snow.

Water and water phenomena are also obviously very newsworthy. Hardly a day goes by without the media reporting on water and water events, which is another aspect of the water experience.

Photo: Andreas Dress

Importance of water for the social economy and social values

A secure water supply enables socio-economic growth, while a scarcity of good quality water can hamper development. Society is changing faster than the climate and has close links with the issue of water resources. Access to clean and safe drinking water establishes the frameworks for business development, housing construction, regional development, and public health and well-being. However, development and growth risk having a negative impact on water resources and increase the need to protect water resources and to ensure water supply in the long term.

Water is a natural resource that is vital for sustainable development. Access to water is essential for socio-economic development as well as for healthy ecosystems and human survival. It is therefore essential to remain aware that water is a finite and irreplaceable resource that can only be secured through sustainable management. But how is water valued? How is its value made visible?

The UN World Water Development Report[49] proposes a valuation of water based on its value for:
- water resources and ecosystems
- infrastructure for the storage, use, re-use or supply of water
- water services, primarily drinking water, sanitation
- production and socio-economic activities, such as food and agriculture, energy and industry, business and employment
- socio-cultural values of water, including recreational, cultural and spiritual attributes

49) UN WWDR 2021 "Value of water"

By definition, the socio-economic value of water corresponds to what the community is willing to pay, or do without, in order to access water. There are many different methods for valuing socio-economic values. What is common to most of them is that they are often based on assumptions that involve fairly large uncertainties. Turnover related to water use and impact can be seen as a rough measurement of socio-economic value but is not always accurate. In addition, it is difficult to estimate the economic value of water as it has many benefits as well as monetary and non-monetary values.

A study based on economic production theory and business economics estimated that Mälaren's water system generates significant socio-economic values. The total figure for the benefits produced was estimated at SEK 127 billion per year if it includes the great potential for land development of the area that the lake supplies with drinking water. The values primarily accrued to the consumers/operators who pay relatively little for a sustainable water system, while those who ensure sustainability and water availability, such as water utilities, are underfunded to be able to fulfil their assignments in the long term. [50] [51]

Lack of economic incentives

Water is seen as a collective resource. Water is not priced in a market, which means that there are no economic incentives to protect or provide water and other water-related values the risk that the water resource is subjected to overexploitation or pollution.

For example, drinking water is priced according to the cost of pumping, purifying and delivering the water – but the water itself is not priced. There are few incentives to save water, and methods to reduce consumption are limited to bans on irrigation and information campaigns.

The water pricing inquiry[52] found that Sweden meets the formal requirements for water pricing policy set out in the EU Water Framework Directive. It also found that the current rate of measures taken has not been sufficient to achieve the objective of "good water status". In order to implement cost-effective measures to a higher degree, the inquiry made the assessment that economic instruments need to be used to a greater extent. If the economic and social values of water resources are not established, there is a risk that these values will be overlooked in urban planning and other decision-making situations. By putting a money value on different values, it is possible to evaluate the effects of different decisions, prioritise between different uses, plan cost-effective measures and avoid treatment and restoration costs.

The water authorities have estimated costs and benefits in the proposed action programme submitted in 2021[53]. The cost of the proposed measures was estimated at SEK 24.5 billion, while the benefits to be generated by the action programme were assumed to be SEK 8 billion per year. The conclusion was that the action programme is clearly socio-economically profitable if it is assumed that the benefits will continue to accrue for more than nine years.

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50) The value of Lake Mälaren. Association of Municipalities in Stockholm County 2009

51) Socio-economic value of clean water. Case studies of Lake Vombsjön and Lake Mälaren, Swedish Water. 2014

52) Priced Water SOU 2010:17

53) www.vattenmyndigheterna.se

The value of water for industrial production and activities

Heavy basic industry accounts for approximately 20 per cent of industrial production and 80 per cent of industry's total water abstraction. However, industrial economic growth occurs mainly in segments with little impact on water[54]. Water use efficiency has increased slightly in recent years, meaning lower levels of freshwater use from an economic point of view. The development of the water-dependent industry has generally remained unchanged or has decreased water consumption over the last 20 years despite an increase in production. A major decrease already took place in the 1970s. Development is considered to be driven by streamlining processes and structural changes.

	Agriculture	Total industry	Pulp, paper, paper products	Steel and metal works; metal products
2015	6	2	22	2
2010	7	3	28	3
2005	9	3	28	3

Table. Changes in water use efficiency by industry (thousands of cubic metres of freshwater per SEK millions of value added). Source: SCB[55]

The value of water for agriculture

The heat and drought in Sweden in 2018 hit agriculture, which was one of the most severely affected industries. Estimates of the total cost to Swedish agriculture range from SEK 6 to 10 billion. The extreme weather in summer 2018 also affected Swedish agriculture in subsequent years as buffers in the form of stocks and economic reserves are smaller than normal[56]. In Sweden, agricultural water abstractions for irrigation and animal husbandry account for only 3 per cent of total water abstractions. The corresponding figure globally is 70 per cent[57]. Even if the Food Strategy's objective of competitive agriculture and increased food production were to be realised, there is not expected to be a significant increase in demand for water[58]. However, regional variations can be great

Agriculture usually faces a problem of too much water. Increased precipitation will lead to more water in the landscape and is likely to result in increased frequency of elevated soil water levels and flooding, which can cause economic damage to agricultural holdings through reduced yields, soil damage, increased labour and production costs, reduced utilisation of fixed assets, losses of plant nutrients and increased use of pesticides[59]. Much of the most productive land is located in low-lying areas near lakes and watercourses. These are the same lands that may need to be used for flood protection and measures to reduce nutrient leaching as well as to improve water quality.

54) Economic structures and environmental impact of water districts 2018, SCB Environmental Accounts MIR 2019:1, 2019

55) Goal 6 – Clean water and sanitation for all (scb.se)

56) Long-term effects of the drought 2018, Report 2019:13, Swedish Board of Agriculture, 2019

57) FAO. 2020. The State of Food and Agriculture 2020. Overcoming water challenges in agriculture. Rome.
https://doi.org/10.4060/cb1447en

58) Agriculture's need for water supply, Report 2018:18, Swedish Board of Agriculture, 2018

59) Flooding! Society's emergency preparedness and prevention of flooding that affects the agricultural sector, Report 2016:01, Swedish Board of Agriculture, 2016

Municipal water and wastewater services

The municipal water and wastewater services (water supply) have a turnover of around SEK 20 billion per year. Swedish Water estimates that investments need to increase significantly from current levels of approximately SEK 16 billion to almost SEK 23 billion per year over the next 20 years in order to ensure that the infrastructure's function is maintained, that water services can be expanded according to need and that future demands can be met. Tariffs need to be increased and almost doubled over the next twenty years. However, the needs and conditions are very different in different municipalities.

The total turnover of the water sector is estimated at just over SEK 75 billion per year. The sector directly and indirectly employs more than 30 000 individuals, which is approximately three times more than the number employed in the mining industry. In order to maintain a good water service, the rate of investment is estimated to need to increase by an average of 40 per cent compared to current levels. However, the needs and challenges vary greatly depending on whether they concern metropolitan regions characterised by strong growth or sparsely populated municipalities in areas suffering from depopulation[60].

Approximately 86 per cent of drinking water comes from municipal waterworks. The single largest relative expenditure by households is on housing (20 per cent), recreation and culture (16 per cent), transport (13 per cent) and food (10 per cent).[61]. Household expenditure on water and sewage costs is less than one per cent of average annual household income.

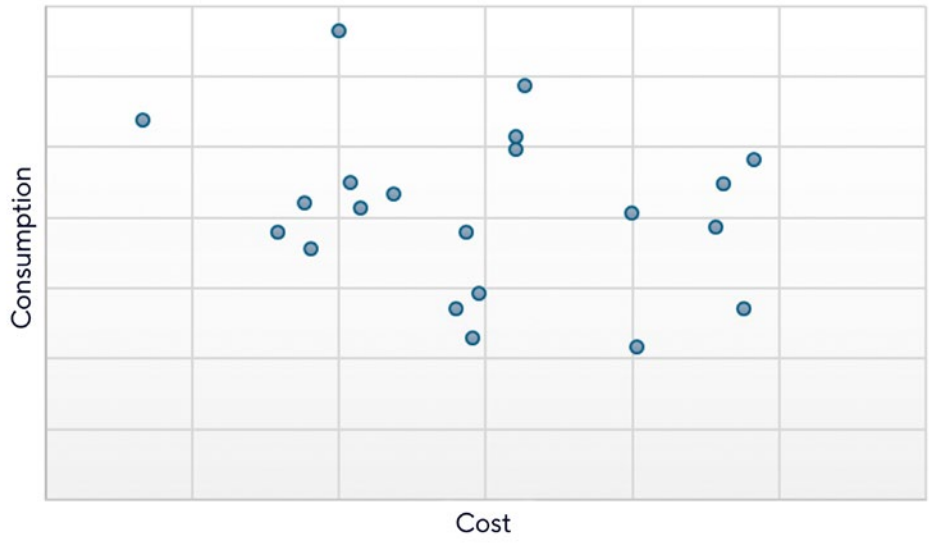

Figure. When comparing between counties, there is no clear relationship between consumption and cost per cubic metre of drinking water[62].

The link between the price of water and consumption is weak in Sweden. Consumption per person is slightly higher in Sweden compared with the rest of Europe. However, the price varies more in Europe, by a factor of 8, but again there is no clear link between price and consumption[63]. In a county-by-county comparison, the price of municipal drinking water varies approximately by a factor of two, while consumption varies approximately by half as much[64]. This could be interpreted as meaning that a price increase of 10 per cent

60) Investment needs and future costs for municipal water and sewage – an analysis of investment needs 2020-2040, Swedish Water 2020.

61) Household expenditure (HUT) 2012, SCB 2014.

62) Modelling Household Water Demand in Europe, Arnaud Reynaud, JRC Report EUR 27310, 2015

63) Europe's water in figures, EurEau 2017

64) JRC 2015

can be expected to result in a 5 per cent reduction in consumption, but the relationship is weak and there may also be other underlying factors. The differences in the level of charges between different municipalities can be large and are primarily due to the fact that the cost of building and operating the water supply systems varies due to different conditions, such as the municipality size, location, type of urban development, distances, topography, population density, the number of activity areas, raw water source, etc.

Consumption of bottled water is relatively limited in Sweden, which is often explained by the generally high quality of tap water. Nevertheless, we spend an estimated SEK 4 billion[65] on bottled water every year – a figure that is expected to grow. This is despite the fact that bottled water is almost 250 times more expensive than tap water and that the transport of packaged water annually produces more than a thousand times more carbon dioxide emissions than the same amount of tap water.

The development in Sweden is demographically characterised by population growth and an ageing population, while strong urbanisation is taking place at the same time. The metropolitan perspective is therefore important in the discussion on the future supply of drinking water, but also its opposite, where the systems and their financing are subject to particular kinds of local pressures caused by depopulation.

Climate change generates new costs, opportunities and needs

Many urban environments can be seriously affected by rising water levels and torrential rainfall. Strategies to combat these threats often involve blue-green nature-based solutions, a priority of the EU's climate adaptation strategy. Urban climate adaptation not only reduces the risks of flooding, but can also contribute to local economic development and generate green jobs. Urban greening improves the local climate during hot periods and helps reduce greenhouse gas emissions. Taken overall, flood risk reduction measures can increase the competitiveness and attractiveness of a city, contributing to a stronger economy and development.

Experiences from torrential rainfall in Copenhagen (2011) and Malmö (2014)

In 2011, Copenhagen was hit several times by heavy torrential rainfall. On 2 July 2011, 150 millimetres fell in two hours, causing flooding and significant material damage, more than EUR 800 million in insurance claims alone.

A cloudburst plan was developed for Copenhagen that divides the city into seven different catchment areas. A process is now underway to transform asphalt surfaces into green spaces that collect and channel the water away. Most of the funding comes from an approximate 20 per cent increase in charges for stormwater management. The main focus is on avoiding the discharge of stormwater into the sewerage system, creating flood zones and infiltration areas, as well as diverting large amounts of water above ground[66].

According to HOFOR (Hovedstadsområdets Forsyningsselskab), 400 projects have been launched in 2021 and will continue for at least another 15 years. The measures drawn up for Copenhagen to protect the city from torrential rainfall are many and varied in nature. Some aim to expand and increase the capacity of the closed water system. Other solutions include using streets and cycle paths as runoff routes to divert water away from the city to canals, parks, buffer areas and the sea. In addition, blue-green solutions that can buffer and retain large amounts of water are under consideration. The final cost is estimated to amount to DKK 16 billion[67].

The worst torrential rainfall to hit Skåne, and Malmö in particular, fell on 31 August 2014. Parts of Malmö were hit by 100 millimetres of rain in 24 hours. Stormwater systems were unable to cope with the large amounts of water and several areas of the city were flooded. The direct cost of the torrential rainfall is estimated to amount to at least SEK 600 million. Most of the costs relate to damage to buildings. Together with the VA SYD water company, the City of Malmö has drawn up a Cloudburst Plan that provides a long-term and concrete action plan to prepare the city for torrential rainfall[68].

65) According to Swedish Water, we drink approximately 25 bottles of bottled water per person per year.

66) The climate adaptation inquiry report SOU 2017:42 Who is responsible?

67) https://www.hofor.dk/baeredygtige-byer/udviklingsprojekter/skybrudssikring/skybruddet-2011/

68) Cloudburst Plan for the City of Malmö, adopted by the City Council 2017, Skyfallsplanmalmostad.pdf

Hydropower, a statistical water user outside the statistics

Hydropower has had and still has great socio-economic importance. The importance of hydropower is likely to increase as it is an important part of the efforts to achieve the goal of a carbon-free society by 2045. Swedish hydropower will be environmentally adapted over the next 20 years, which may be of great significance to certain water systems. Adaptation measures will basically be implemented where they are assessed as socio-economically profitable and essential from an environmental perspective. There is limited experience of socio-economic assessments of environmental measures in hydropower in Sweden[69].

Hydropower represents large values and very large levels of water use. However, SCB's statistics on water abstractions do not include hydropower, even though it can be argued that hydropower accounts for by far the largest water abstractions, in the order of 500 times more than the combined sum of all other abstractions.[70]. Hydropower affects the flow through regulation, which is not entirely comparable with, for example, water abstractions for irrigation. Small hydropower plants often affect the flow marginally, while large ones can affect the whole of the hydrological annual cycle[71].

National plan for modern environmental conditions for hydropower.

On 25 June 2020, the Government decided on a national plan for modern environmental conditions for hydropower and amendments to the Ordinance on Water Operations. The assessments of the environmental conditions for hydropower should lead to the greatest possible benefit for the aquatic environment and an efficient national supply of hydropower electricity. The plan sets out a national holistic approach to providing hydropower with modern environmental conditions in a coordinated manner, with the greatest possible benefit for the aquatic environment and for national efficient access to hydropower electricity.

All hydropower plants in Sweden will be assessed systematically on the basis of the national plan, such as by facilitating the simultaneous assessment of all power plants in a section of river with the possibility of coordinating decision-making documents. This leads to a coordinated assessment and simplifications compared with today's approach, and increased environmental benefit and reduced costs when measures are taken where they have the greatest effect.

The national plan provides as guidance for the authorities that bring action or give opinions in the assessments. The plan also provides guidance for the authorities that work with or make decisions on the management of the quality of the aquatic environment, such as the county administrative boards. A party conducting an activity subject to licensing for the production of hydropower electricity must ensure that the activity has modern environmental conditions.

For efficient access to hydropower electricity, the plan must promote, among other things, the greatest possible regulatory capacity[72], electricity preparedness and national, regional and local stability in the transmission network, and ensure that the need for increased capacity is met in existing power plants.

Figure. Implementation of the national plan should lead to the greatest possible benefit for the aquatic environment and an efficient national supply of hydropower electricity.

69) Socio-economic assessments of dam removals, Report 2020:656, Energiforsk.

70) Increased knowledge of water abstraction in Sweden, SMHI Hydrology 126

71) With Report on the government assignment to review the HARO values in the national plan for modern environmental conditions. Swedish Agency for Marine and Water Management 2021.

72) Hydropower's regulatory contribution and value to the electricity system, Swedish Energy Agency ER 2016:11

Importance of transport infrastructure

Transport infrastructure is important in the work on planning for water resources and drinking water supply. The interaction between transport system planning and urban planning is a prerequisite for being able to achieve sustainable cities and regions. The Swedish Transport Administration also emphasises that the agency's involvement in urban planning is focused on integrating the planning of buildings, infrastructure and transport.

The construction, operation, maintenance and use of road and rail infrastructure often involve an impact or risk of impact on water and water-related values. The impact may consist of pollution or risk of pollution of water (both diffuse and direct), impact on water flows and levels, and impact on the shape, location and continuity of water. The risk of pollution requires extra attention when it comes to water resources of significance for drinking water supply or with high natural values. This also applies to roads and railways that form migration barriers for fish and other aquatic organisms. Impact on flows and levels can also have a negative impact on other important social interests, such as buildings and installations with a groundwater-dependent foundation[73]

Planning for infrastructure must take into account the need to protect surface water and groundwater as well as consider the protection of future drinking water needs in an urbanised social development. Swedish Transport Administration[74] has developed a methodology for risk management and risk analyses. The emphasis is on conducting risk analyses, with a detailed analysis of the need for measures. Measures are then chosen, which are further studied in a socio-economic analysis. The methodology will be developed, including the quality assurance of a list of protective measures and standardised costs of measures.

Social value of water resources

A water resource's social values include effects on nature and ecosystems as well as on society in general. A water resource has an impact on human well-being and the development of human social contexts and organisations, which in turn can affect water resources.

The social value of water can be divided into physical, social and psychological values. Here, the physical part refers to the importance of water for health and well-being, individually and in a landscape perspective. The social part refers to the importance of water for cohesion, participation and equality, while the psychological part refers more to knowledge, culture, tradition and religion. Attempts have been made to systematically assess the social value of water, but further research and development will be required due to the complexity of the issues and the lack of input data[75].

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73) Swedish Transport Administration report. Impact of the transport system on surface and groundwater. Government commission 2021.

74) The Swedish Transport Administration's report Surface and groundwater protection – Methodology for risk management and risk analysis
and principles for selecting measures, TRV publ 2020:171.

75) Defining and evaluating the social value of regional water resources in terms of energy, Zening Wu et al, Water Policy 21 (2019) 73–90, 2019

Photo: Ingvar Lagenfelt

Water and social planning

Social planning is carried out by many actors and at different levels. Public administration is carried out by municipalities and state authorities on the basis of the framework decided by the Swedish Parliament and the Government. All operators plan for their activities. Good management of national, regional or municipal planning provides better planning frameworks for infrastructure, buildings, hydropower, mines, industrial establishments, wind power, etc.

Regional and municipal planning

The county administrative board advises the municipality and is responsible for ensuring that the interests of the state are served in the planning. Regional water supply plans that are drawn up by county administrative boards are important as a basis for physical planning at both regional and municipal levels. The plans form a basis for the planning in relation to the county's water resources, how much water is available, what other stakeholders need water, and what claims there are on available resources. The plans provide support for the county administrative boards in connection with advisory services, reviewing outline and detailed plans, assessing water operations and environmentally hazardous activities, as well as the focus for the protection of water resources. The plans are also a basis for the work on climate adaptation, such as to plan for situations with water scarcity or too much water[76].

Both regional plans and outline plans set out the long-term development for how land and water areas will be used, but with different scope and degree of detail. In physical planning under the Planning and Building Act, many different interests must be considered, including the possibilities of providing water supply and preventing water pollution.

The municipalities have local responsibility for planning for society's development and the use of land and water, and changes to buildings or infrastructure, etc. A municipality's planning needs to include all of its various roles in relation to the water issue. Planning should be future-orientated but still meet the challenges that face the municipality in the short term. The planning must also fulfil the legal requirements in, for example, the Environmental Code, the Planning and Building Act and the Public Water Services Act.

There are often several different interests within a given geographical area that need to be considered in relation to the use of land and water. The planning process analyses the relevant conflicts of interests and objectives that have been identified, and the final plan sets out which interest or use should take precedence.

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76) Guidance on regional water supply planning. The Swedish Agency for Marine and Water Management 2020:1.

Water planning is part of the municipality's overall planning. It is a necessity to plan for expansion, renewal and other measures for a secure water supply. Sweden's municipalities are facing major challenges when it comes to water supply. Measures need to be implemented to improve the treatment of wastewater in order to achieve good status in receiving waters. The protection of water supply points needs to be strengthened and stormwater management needs to be made more sustainable and climate-adapted in the long term.

National planning

Several government agencies are responsible for planning according to their area of responsibility. The Swedish Transport Administration, plans for the state infrastructure in an infrastructure plan for roads, railways, shipping and aviation. The Swedish Transport Administration, Swedish Maritime Administration, and Swedish Transport Agency implement the planning and regulation of the activities.

The Swedish Environmental Protection Agency, Swedish Agency for Marine and Water Management, Swedish Civil Contingencies Agency, Swedish Food Agency, Swedish Chemicals Agency, Swedish Forest Agency, Swedish Board of Agriculture and the county administrative boards/water authorities are the state authorities that primarily plan, regulate and implement different areas of administration in support of sustainable land and water use.

Strategic water planning

There is a need for strategic water planning that takes into account climate change and other societal changes. Strategic water planning deals with creating good conditions for the sustainable use of land and water and working with a goal-oriented and long-term approach in a changing world. Creating a coherent approach provides a good basis for making decisions on the use, development and protection of water at municipal, regional or national level. The approach also generates conditions for more efficient resource management internally and in collaboration with other responsible parties or actors. Strategic water planning is proactive rather than reactive. The work by municipalities on outline plans can fulfil this function provided that they are characterised by a catchment area perspective and are evaluated and adapted to climate change, in particular with regard to flooding
and drought.
Water planning involves collaboration between the parties that use and have an impact on the water's resources, quality and values.

Creating coherent and sustainable water planning requires a clear commitment from responsible parties and policy makers, a structured approach and a robust organisation that can handle strategic planning, governance and follow-up, and encourage participation and local management.
Key factors for successful and strategic water planning include[77]:

1. Consensus between ambitions and legal requirements.
2. A robust organisation with a clear decision-making process and division of responsibilities.
3. A common knowledge base on problem definition and the need for action.
4. Prioritisation and methodical implementation of measures and securing funding through internal coordination and external collaboration.
5. Follow-up and evaluation of the work, both organisational and practical, for continued development and more effective achievement of objectives.

77) Municipal strategic water planning. Developed by the County Administrative Board in Stockholm/ LIFE IP Rich Waters 2018

Urban planning sets the frameworks for the long term, and therefore strategic water planning needs to take climate change into account. Water planning needs to be an integral part of more coordinated national planning that creates the conditions for managing complex societal challenges in order to meet the required transition, which is an issue raised by the Swedish Council for Environmental Objectives in its programme for a framework for national planning[78]. This creates better conditions for efficient resource management. Successful water planning results in several synergy effects that favour outdoor recreation, increase the attractiveness of the municipality, prevent the negative consequences of flooding, and prevent damage that would potentially cost many times more to remedy than the water management itself. There is a great need for good planning documentation for water resources, in particular in growing cities. This saves money in the municipality's planning work because it limits investigation costs in individual detailed plans.

78) Framework for national planning, Swedish National Board of Housing, Building and Planning, Report 2022:05.

Photo: Frederik Falinski

Environmental objectives and legislation

Legislation relating to water resource management can be found in food legislation (drinking water), environmental legislation, planning and building legislation and, not least, the EU directives that include the Water Framework Directive, the Habitats Directive, the Urban Waste Water Treatment Directive and the Floods Directive.

Despite a comprehensive regulatory framework, few provisions specifically address water as a resource. There is no system that collectively manages the water resource within a catchment area. Permits are sought and eventually granted, usually without time limits. It is on a first-come, first-served basis, which means that it is difficult to change water use afterwards to increase social benefits and reduce environmental impact.

A look back

Water has always been important for the individual and for society, as drinking water, for hygiene, food, energy and transport routes. As early as the 1200s, water regulations were introduced in regional laws that can be regarded as general rules of conduct in order to ensure that the resources could be utilised by everyone. At the same time, the regulation followed the properties, which were also a basis for tax legislation.

In the 1700s to 1800s and early 1900s, water legislation focussed on the use of land and water areas for society's supply of food, energy and industrial products. At that time, Swedish water law provisions were divided into several different laws and regulations. In 1918, much of the legislation was brought together in one law, the 1918 Water Act, which regulated the right to, and construction in, water, including water regulation, and then particularly with regard to hydropower.

Industrial production and the introduction of WCs in the 1920s gave rise to significant environmental pollution, and water legislation also took on the character of environmental protection legislation. The 1950s saw the introduction of the first specific water and sewerage legislation in order to provide water supply and sewerage services to urban centres and to regulate responsibilities between the municipality and the individual.

The 1918 Water Act was replaced by the 1984 Water Act, which ceased to apply in 1999 when the Environmental Code was introduced. The water law regulatory system was then divided into Chapter 11 of the Environmental Code and the so-called Residual Water Act.

With the introduction of national parks at the beginning of the 1900s, shoreline protection legislation in the 1950s, the Nature Conservation Act and the Environmental Protection Act at the end of the 1960s, and a revision of the Water Act in 1983, natural environments, water resources and measures against polluting discharges became increasingly important. Extensive efforts to protect and preserve ecosystems have been made over the past 50-plus years, with generally favourable results.

Sweden's environmental objectives

The focus of Swedish environmental work is largely determined by the work that has continued in Sweden since 1999 in connection with the Environmental Code entering into force and the Swedish Parliament adopting the Swedish environmental quality objectives. Three of the environmental quality objectives adopted by the Swedish Parliament relate to freshwater: Flourishing Lakes and Watercourses, High-Quality Groundwater and Thriving Wetlands. These objectives concern various aspects of water quality, including flows, biodiversity and habitats, but also cultural heritage values and outdoor recreation. In addition to these, water is also affected by the environmental quality objectives: Natural Acidification Only, Zero Eutrophication, A Non-Toxic Environment, A Good Built Environment and A Rich Plant and Animal Life. The implementation of the Water Framework Directive and the Habitats Directive will contribute to the management of our freshwater environments and their biodiversity and to achieving several of the water-related environmental quality objectives.

EU Directives

The Water Framework Directive

The EU Water Framework Directive, the Environmental Code and the Water Administration Regulation provide the basis for Sweden's water management efforts. Five county administrative boards, designated as regional water authorities, are responsible for managing the aquatic environment in their respective water districts. Status and environmental quality standards (EQS) are established for all water bodies (lakes, watercourses, groundwater and coastal waters) within the district's catchment areas.

Water management shall promote the sustainable use of Europe's water resources by protecting available water resources, preventing further deterioration and aiming for increased protection and improvement. By these means, water management will help to ensure the availability of good quality water for the needs of society as well as nature. All water bodies shall be subject to monitoring programmes to enable regular classification of ecological and chemical status for surface water and quantitative and chemical status for groundwater.

The EU Water Framework Directive provides a framework and objectives for maintaining or improving the aquatic environment, described primarily through biological quality elements. These can be supplemented by water chemical and water physical (hydromorphological) parameters.
The Water Framework Directive is complemented by the Groundwater Directive and the Priority Substances Directive and supported by other EU initiatives such as the Marine Strategy Framework Directive, the Biodiversity Strategy, the Eel Regulation and the Nitrates Directive.

The Drinking Water Directive

The aim of the Drinking Water Directive is to ensure healthy and clean drinking water that can be consumed without risk to human health. The EU adopted a new Drinking Water Directive On 16 December 2020. One of the more significant changes to the 2020 Drinking Water Directive is a transition to a risk-based approach to drinking water safety that covers the whole chain from catchment area, abstraction, treatment, storage and distribution of water to the point of compliance. The new directive will set requirements for more actors to be involved in the drinking water chain. The directive shall be incorporated into Swedish law by 13 January 2023 at the latest, after which there will be a gradual practical implementation of the various parts of the Drinking Water Directive.

Urban Waste Water Treatment Directive

The Urban Waste Water Treatment Directive has been incorporated into Swedish legislation, mainly through the Ordinance on Environmentally Hazardous Activities and the Protection of Public Health, the Environmental Assessment Ordinance, and the Swedish Environmental Protection Agency's regulations (NFS 2016:16) on the treatment and control of wastewater discharge from urban areas. The Urban Waste Water Treatment Directive is under review.

Floods Directive

Following major flooding in Europe, the EU adopted a directive for flood risks in 2007 that regulates the management of floods. The aim of the Floods Directive is to reduce the adverse effects of flooding on human health, the environment, cultural heritage and economic activity. The Directive is implemented through the Flood Risk Ordinance and MSB's Risk Management Plan regulations.

Intense or prolonged rainfall can lead to a risk of flooding in low-lying areas. These areas are to be mapped in Sweden. MSB is the responsible authority and carries out the work in close cooperation with the county administrative boards. MSB carries out the analyses and identifies areas with significant flood risk based on a number of criteria. The county administrative boards produce flood risk maps and establish risk management plans for the designated areas.

The Habitats Directive, Birds Directive and Natura 2000

The Habitats Directive and the Birds Directive are the cornerstones of the EU's nature and biodiversity policy. The Directives state that species and habitats in areas included in the Natura 2000 network should be afforded special protection. The aim is to ensure that a favourable conservation status is achieved for the species or habitats covered by the protection.

Natura 2000 is a network of protected areas in the EU that aims to protect and conserve biodiversity. In Sweden, there are eight different types of lakes and watercourses that are covered by the Directive. In a Natura 2000 area, habitat types should be able to develop in a favourable way and species should grow into viable populations. The county administrative board proposes areas, which are reviewed by the Swedish Agency for Marine and Water Management and the Swedish Environmental Protection Agency. The Swedish Environmental Protection Agency proposes to the Government which areas should be included, and the Government decides whether to notify these to the EU.

For water resources included in Natura 2000 areas, Chapter 7, § 27 Environmental Code, favourable conservation status must be achieved. The more specific requirements for achieving favourable conservation status in a Natura 2000 area are set out in the conservation plan and/or management plan to be drawn up for such areas. These requirements are often of great importance in the assessment and reassessment of water operations.

The Bathing Water Directive

Most citizens expect good quality bathing water. However, the directive-driven quality requirements that exist only apply to just over 400 large and frequently visited bathing areas at lakes and coastal waters, but there is the opportunity for municipalities to have a higher level of ambition for citizens. The Swedish Agency for Marine and Water Management provides guidance to municipalities on how to monitor and communicate water quality at bathing areas. Measures must be taken if the water quality is not satisfactory.

Environmental Code

The water law provisions are primarily found in Chapter 11, Environmental Code (1998:808), in the Ordinance (1998:1388) on water operations and in the Act (1998:812) Containing Special Provisions concerning Water Operations, the so-called Residual Water Act[79].

Water operations are defined in Chapter 11, § 3 of the Environmental Code as

1. construction, modification, repair or removal of an installation in a water area,
2. filling or piling in a water area,
3. the abstraction of water from a water area,
4. excavation, blasting or clearing in a water area,
5. any other action in a water area aimed at changing the depth or position of the water,
6. the abstraction of groundwater or the construction of an installation for that purpose,
7. the supply of water to increase the quantity of groundwater or the construction of an installation or other measure for that purpose; or
8. land drainage.

The main rule is that water operations are subject to licensing or notification. Permits for water operations are examined by the Land and Environment Court, with the exception of land drainage, which is examined by the county administrative board. A notification is handled by the supervisory authority. As a basic rule, the county administrative board is the supervisory authority for water operations, but supervision can be delegated to the municipality in a special arrangement according to procedural rules in the Ordinance on Environmental Supervision. The Swedish Agency for Marine and Water Management is responsible for supervisory guidance for water operations that are not land drainage. The Swedish Environmental Protection Agency has supervisory guidance on land drainage.

Although the main rule is that water operations are subject to licensing or notification, there are a number of exceptions to the main rule in Chapter 11, §§ 11 and 12 of the Environmental Code.

79) The Swedish Agency for Marine and Water Management (2018). Distribution of water in the wake of drought

According to Chapter 11, § 11 of the Environmental Code, a licence is not required for

1. a water supply point for one or two-family properties or an agricultural property's domestic consumption or heat supply
2. Construction of installations for the cultivation of fish, mussels or crustaceans
3. Construction of a heating installation, if the measure does not concern a water supply point

Nor is a licence required under Chapter 11, § 12 of the Environmental Code if it is obvious that neither public nor private interests are harmed by the impact of the water activity on water conditions. A review of the exemption provisions may therefore be needed in areas where there is a shortage of water.

The Residual Water Act also contains some relevant provisions, including basic requirements for access to water.

The water law rules govern water abstraction rights and allocation mechanisms between different stakeholders. Water law has set the rules of the game in society for a long time and there are therefore a large number of activities that are not currently registered or legally regulated.

Water law has a long tradition of individual assessments of activities. There are certain advantages to individual assessments:

1. Circumstances in the individual case can be taken into account
2. Resources can be directed to where they are most needed

The views of different stakeholders can be considered and different interests can be taken into account. At the same time, there is criticism of complicated and lengthy assessment processes and the fact that permits are often technically complex. Larger lake regulations can consist of many different sub-judgements and it can be difficult to build an overview of what applies. A permit is limited in time only in exceptional cases, and this also means that a new start is difficult if conditions change.

Everyone has control over the water within their own property. This is the starting point and has been the case since water legislation was introduced in 1918.

In existing legislation, the individual's right to apply for a permit to use water must be carefully weighed against water availability, the impact on water-dependent ecosystems, and the management of land and water.

The specific conditions for water operations are of significance when assessing the permissibility of an abstraction. The purpose and social benefit of an abstraction must be examined in an assessment. Normally, limiting rules are announced for abstractions that are linked to low water levels or flows. Account is also taken of other property interests affected by the same water system.

A water operation may not be carried out in such a way that it impedes another activity that can be assumed to affect the same water resource in the future. Consideration must be given to activities that are likely to be carried out in the not too distant future, such as within a period of 10 years.

A water activity with a permit receives very strong legal protection against future environmental and nature conservation requirements, for example, or future claims and needs.

Land drainage

The regulations differ slightly for land drainage, which is also a water operation. Land drainage is generally prohibited in most of southern Sweden, but the county administrative board can assess whether an exemption can be granted and issue a permit for land drainage. Parts of northern Sweden are also subject to a ban on land drainage, while other areas require a permit for land drainage from the county administrative board. The county administrative board is the supervisory authority and Swedish Environmental Protection Agency has national responsibility for land drainage issues and has supervisory guidance responsibilities.

Land drainage involves carrying out measures that change the water conditions in the land. The measure is carried out to make the land suitable for use, for example, for agriculture or housing construction. Land drainage is the removal of unwanted water through drainage or trenching, or protection against water, such as embankments. In central and southern Sweden, land drainage is prohibited due to the disappearance of many wetlands. Land drainage requires a permit and an exemption is also required in areas with a ban.

Water protection area

By establishing water protection areas, an existing or future drinking water supply point can be protected with special protection regulations. Provisions on this are contained in Chapter 7, Environmental Code. The decision on a water protection area can be made by the county administrative board or municipality. In Sweden, there are 1900 public water supply points, of which 70 per cent have an approved water protection area, but many of these are old and need to be updated.

National parks and nature reserves to preserve biodiversity

Water bodies deemed worthy of protection can be protected through formal area protection under Chapter 7, Environmental Code. The most important forms of protection to protect aquatic environments are national parks, nature reserves, biotope protection and nature conservation agreements, all of which often involve restrictions on how land and water resources may be used.

National parks can be established to preserve large continuous areas of a particular landscape type in its natural state or in an essentially unchanged condition. Regulations on the care and management and on restrictions on the right to use land or water within national parks may be issued by the Government or the authority designated by the Government. Sweden has 30 national parks.

A county administrative board or municipality may designate a land area or water body as a nature reserve for the purpose of preserving biodiversity, maintaining and preserving valuable natural environments or meeting the needs of areas for outdoor recreation. A nature reserve may also be designated for an area that is needed to protect, restore or create valuable natural environments or habitats for species worthy of protection. The decision to designate is made by the county administrative board or municipality. The county administrative board or municipality draws up proposals for designation in consultation with Swedish Environmental Protection Agency and, if it concerns important aquatic environments, with the Swedish Agency for Marine and Water Management. Sweden has more than 5000 nature reserves and many contain aquatic environments.

Small areas with special habitats for plants and animals can be protected as biotope protection areas. No activities or measures may be carried out within a biotope protection area that could affect the natural environment. The aim is to preserve the natural values of the area. There are two types of biotope protection: 1. According to a government decision, some areas are protected throughout the country, known as general biotope protection: examples of areas affecting aquatic environments are springs and their surroundings wetland, small waters and wetlands. 2. Biotopes that a county administrative board, municipality or Swedish Forest Agency may decide in individual cases should constitute a biotope protection area. The Swedish Forest Agency may decide on 19 biotopes and the county administrative board/municipality on 16. Several of the biotopes consist of aquatic environments with surrounding land.

A limnic nature reserve is aimed at protecting lakes and watercourses and their natural values. Known threats to the designated aquatic values must be regulated from a catchment area perspective, i.e. the impact on aquatic environments from surrounding land. Table 3 shows the number of particularly valuable areas that the county administrative boards deemed to be protected in 2017, and the number of areas that are wholly or partly unprotected. Work on the long-term protection of lake and watercourse environments with high natural values is making slow progress. Many of our most valuable areas still lack adequate protection. The objectives for protection are far from being met and the majority of the areas identified as worthy of protection lack adequate protection.

NATURE	Number of sites		Area		Lake area		Watercourse area	
Yes	138	26%	992 822	16%	237 726	20%	1 757	0%
No, the area is largely protected but the protection is insufficient to safeguard the conservation values in the long term.	150	29%	3 808 405	62%	298 709	25%	89 867	26%
No, the area lacks or has some protection, but the protection is insufficient to safeguard the conservation values in the long term.	235	45%	1 351 376	22%	679 183	56%	260 139	74%
No reply	2	0%	535	0%	279	0%	0	0%
Total	525	100%	6 153 138	100%	1 215 897	100%	351 763	100%

Table. The County Administrative Board has identified 525 water-related natural areas as particularly valuable, of which 26 per cent are deemed to have adequate protection. Area is given in number of hectares[80].

Protecting the areas is important for both biodiversity and reduced climate impact and climate adaptation[81]. Area protection forms the basis for a blue-green infrastructure. Protection is based on value cores and key species and is dependent on ecological connectivity in order to preserve and strengthen biodiversity and ecosystems. Management of water in the landscape therefore becomes an important issue that also links to climate adaptation.

The Law on Public Water Services

The municipality is responsible for water and wastewater services in densely populated areas, known as water supply areas, under the Public Water Services Act (LAV). It is the municipality's obligation to provide water supply and sewerage if, with regard to the protection of human health or the environment, it is necessary in a larger context for a certain existing or future development. In such cases, the municipality must determine an operational area where the water services need to be provided and ensure that the need is met through a public water and sewerage plant. The LAV governs the responsibility of the water utility and property owners for stormwater management. Property owners with individual water and wastewater services are responsible for both drinking water supply and wastewater treatment.

The Planning and Building Act (PBL)

According to the Planning and Building Act, all municipalities must have an up-to-date outline plan that aims to set out the focus of long-term sustainable development in the municipality. The consequences of the outline plan must be well described. The outline plan must provide guidance for decisions on how land and water areas shall be used and how the built environment shall be used, developed and preserved. It must also show how the municipality intends to take account of public interests, including water supply.

80) Protection of valuable lakes and watercourses – Report on the implementation of an assignment in the Swedish Agency for Marine and Water Management's appropriation directions for 2017.

81) Roberts CM, O'Leary BC, Hawkins JP. 2020 Climate change mitigation and nature conservation both require higher protected area targets. Phil. Trans. R. Soc. B 375: 20190121

In terms of regional planning, the Planning and Building Act sets out that a regional plan must be drawn up by the region in the counties of Stockholm and Skåne, while it is optional for regions in other counties. The regional plan is similar to the outline plan but instead covers all municipalities in a county. Better conditions for planning are created by the inclusion of a larger geographical area in the regional plan. Among other things, this can facilitate work on developing a more robust water supply by interconnecting the infrastructure between municipalities or regions, and the expansion of more large-scale supply systems.

During the consultation when drawing up an outline plan or regional plan, a county administrative board must coordinate the state's interests and conduct investigations and provide programmes and other planning documentation that are important for the management of land and water in the county. These include national interests and environmental quality standards. Regional water supply plans are important planning documentation for both municipal outline plans and regional plans.

Emergency preparedness

According to the Ordinance on Emergency Preparedness and Surveillance Responsible Authorities' Measures at Heightened Alert, all state authorities, both national and regional, must draw up risk and vulnerability analyses. According to the same ordinance, the authorities with special responsibility for emergency preparedness and the authorities that MSB decides on must submit a report based on the analysis to the Government Offices and MSB every two years. The county administrative boards must draw up regional risk and vulnerability analyses and support other actors who are also responsible for emergency preparedness in the county in their risk and vulnerability analyses. Municipalities and regions carry out risk and vulnerability analyses in accordance with the Act on Municipal and County Council Measures Prior to and During Extraordinary Events in Peacetime and during Periods of Heightened Alert. Every four years, the municipality must compile and report the results of its work on risk and vulnerability analyses to the county administrative board.

Ordinance on Climate Adaptation Work

In 2018, the National Strategy for Climate Change Adaptation[82] was adopted by the Swedish Parliament. The overall objective of the strategy is to strengthen long-term climate adaptation work in Sweden and the national coordination of climate adaptation. The strategy highlights a number of particularly urgent areas for continued work on climate change adaptation. In the strategy, the Government specifically identifies the following areas where climate change adaptation is important:

1. Landslides, debris flows and erosion that threaten communities, infrastructure and businesses.
2. Flooding that threatens communities, infrastructure and businesses.
3. Water supply shortages for individuals, agriculture, and industry.

The work on national adaptation is regulated by the Ordinance on Climate Adaptation Work on the Part of Government Agencies. All 21 county administrative boards and 32 national authorities are affected by the regulation. According to the Ordinance, the authorities are obliged to initiate, support and evaluate climate adaptation work.

The climate adaptation work of the authorities must be based on a climate and vulnerability analysis of how the activity is affected by a changed climate. Objectives and an action plan for the work must be drawn up. In addition, the authorities must report their work on climate adaptation to SMHI on an annual basis. The county administrative boards shall also, within their assignment, coordinate the regional work and analyse how the county and, if necessary, neighbouring counties are affected by climate change, as well as initiate, support and follow up the climate adaptation work of the municipalities.

82) Government Bill 2017/18:163)

Photo: Erda Estremera

Organisation and responsibilities

The organisation and division of responsibilities is complex, and the management of water resources is not coordinated at national, regional or local level. The responsibility is fragmented and is distributed among several ministries and many authorities at national, regional and municipal level. There is no national authority with overall responsibility for the entire water resource.

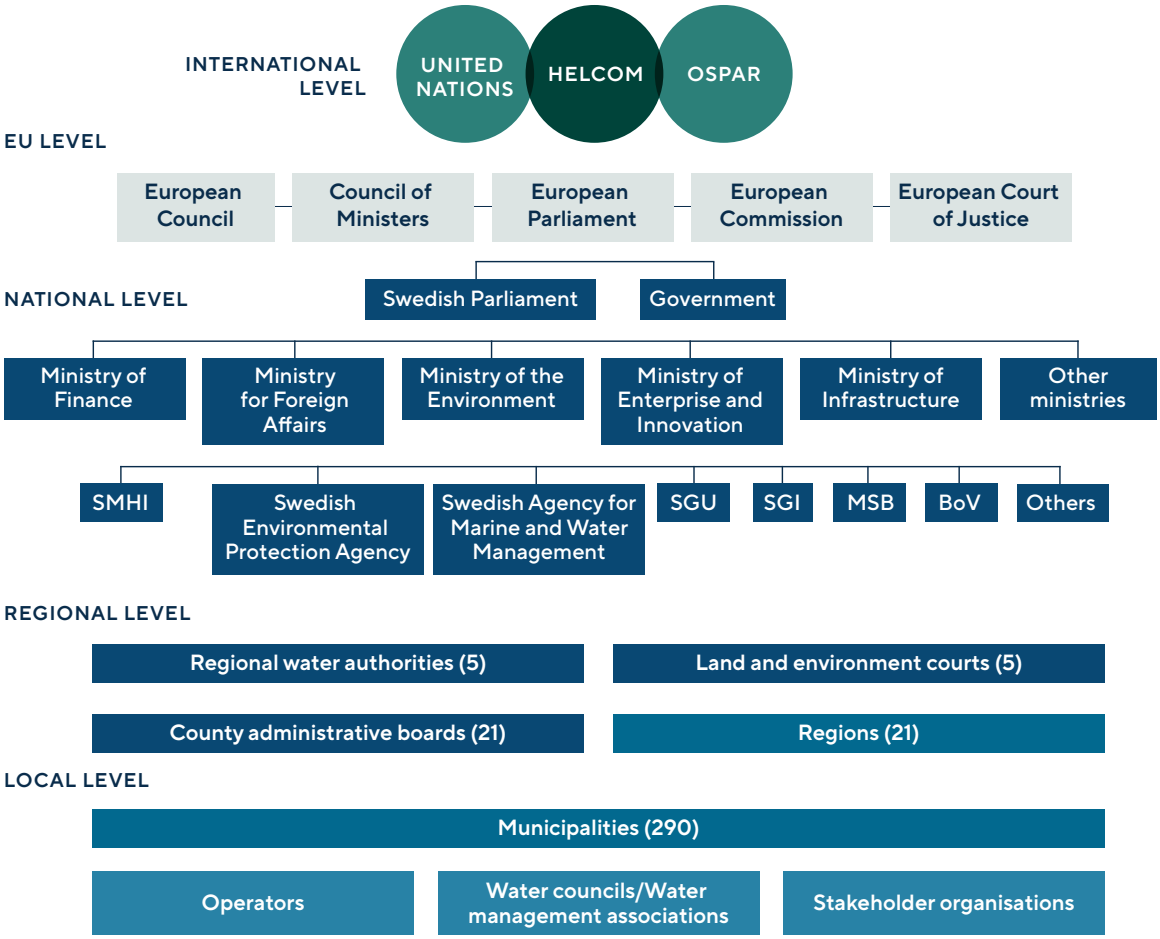

Figure. Actors in water resource management.

At local level

Operators. Swedish legislation places significant responsibility for aquatic environments on all operators. They must meet and monitor the requirements included in their environmental permits and other requirements and acquire the knowledge needed for the nature and scale of the activity or measure in order to protect human health and the environment. Good planning and the implementation of self-inspection, protective measures and precautionary measures are requirements. The county administrative board or municipality is responsible for supervising the activities.

Water councils – water management associations. Water councils are local associations for a watercourse, lake or coastal water with local actors represented, such as municipalities, industry, environmental organisations, sport fishing and power companies. Water councils can be organised in different ways, for example as a non-profit or economic association. Many water councils have been formed from existing water management associations or water associations. The role of water councils is to conduct a dialogue with the authorities and to contribute knowledge about their water area and implement proposed measures at local level.

Interest and non-profit organisations operate on all levels to promote the interests of their members or the environment, and some of them also participate practically in water councils – water management associations. Under the Aarhus Convention, environmental organisations also participate in major decision-making processes on the environment with the right to appeal certain decisions that are important for the environment.

The municipality is responsible for land and water planning through its planning monopoly. The municipality is also responsible locally for environmental protection and nature conservation as well as supervision and assessments under the Environmental Code. Sweden's municipalities are responsible for providing public water services (water and sewage) within an activity area. The municipality is only obliged to provide services for household purposes, but should take into account other needs, such as the need of the emergency services for water for fire-fighting. The municipality can transfer the responsibility for water services to a municipal company or a municipal association. In many municipalities, drinking water supply and wastewater treatment are organised regionally and are based on collaboration. Outside the activity area for water services, the property owner is responsible for drinking water supply and wastewater treatment.

At regional level

Sweden's regions are responsible for regional development, which includes developing goals and strategies for the county's development and coordinating efforts for their implementation.

The county administrative boards have an overall responsibility for coordination in the county and coordinate, among other things, emergency preparedness and climate adaptation work at regional level. The county administrative boards also supervise water operations, the municipality's obligation to provide water supply and water protection areas (decisions and supervision). In regional planning and municipal outline planning, the county administrative board must provide documentation for the municipality's assessments and provide advice on public interests that should be taken into account, including with regard to the opportunities to provide water supply and to prevent water pollution. A county administrative board also has supervisory responsibility for certain issues in detailed plans relevant to water supply, such as the management of national interests, inter-municipal issues, environmental quality standards, as well as health and safety issues. The county administrative board is the regional supervisory authority for nature conservation and environmental protection.

The five county administrative boards, which are regional water authorities, have the main administrative responsibility for managing the quality of the aquatic environment in the water districts in accordance with the Water Administration Regulation and establishing status and environmental quality standards, and decide on action programmes to ensure compliance with the standards.

Land and Environment Courts (MMD) examine cases concerning water operations and cases concerning major environmentally hazardous activities that may affect water. On appeal, Land and Environment Courts also examine decisions by county administrative boards and other state authorities under the Environmental Code or regulations issued pursuant to the Code or under the Act Containing Special Provisions concerning Water Operations.

At national level

The Swedish Parliament decides on laws and the state budget, which can be said to set the frameworks for water resource management. The Swedish Parliament also has supervisory powers, which means that it scrutinises the work of the Government and the authorities. The supervisory powers are intended to ensure that the Government and the authorities comply with the laws and work in an efficient way that creates confidence in public authority. Issues relating to water resource management are mainly dealt with by the Committee on Environment and Agriculture or the Committee on Industry and Trade.

The Government proposes laws, implements parliamentary decisions and manages the state authorities. The Government also has a number of official tasks such as issuing ordinances, appointing heads of authorities and deciding on the allocation of assignments and funding to the authorities.

The Swedish Agency for Marine and Water Management (SwAM) prescribes regulations and provides guidance to the regional water authorities on surface water. SwAM has a management responsibility for lakes, watercourses and seas. SwAM also works on issues related to water protection areas and designates areas of national interest for water supply installations. SwAM is also responsible for the central supervisory guidance under the Environmental Code linked, among other things, to water operations, protection of groundwater and environmental quality standards for water.

SGU prescribes regulations and provides guidance to the regional water authorities on groundwater. Neither SGU nor any other authority has a management responsibility for groundwater equivalent to that of SwAM for lakes, watercourses and seas. SGU provides a range of planning documentation on groundwater through its responsibility to investigate Sweden's soil, rock and groundwater and to compile information on groundwater in Sweden.

The Swedish Food Agency is responsible for the national coordination of drinking water issues, especially in the field of climate change adaptation, as well as crisis and contingency planning for drinking water supply. The Swedish Food Agency is responsible for the regulatory work on drinking water quality. The Swedish Food Agency is responsible for information and providing advice on individual drinking water supplies.

The Swedish National Board of Housing, Building and Planning provides guidance on spatial planning and the management of land and water areas. The Swedish National Board of Housing, Building and Planning is also the coordinating authority for the national climate adaptation work for the built environment.

SMHI provides planning and decision support for weather-dependent and water-dependent activities. The Swedish National Knowledge Centre for Climate Change Adaptation is located at SMHI. SMHI contributes hydrological and oceanographic knowledge, models and tools.

The Swedish Civil Contingencies Agency, MSB, is tasked with developing society's ability to prevent and manage accidents and crises. MSB is the designated competent authority for the EU Floods Directive and coordinates and provides guidance on the implementation of the Directive. MSB produces important data that can be used in the work on water supply plans, such as flood maps and outline stability maps for built-up areas.

The Swedish Board of Agriculture provides for the considerations to be taken in agriculture to protect water quality. The Swedish Board of Agriculture has a centre of excellence for sustainable water management in agriculture, which provides advice on water management as water supply in agriculture. The Swedish Board of Agriculture distributes subsidies and grants through the Rural Development Programme to promote biodiversity and aquatic environments in the agricultural landscape.

The Swedish Forest Agency provides for the considerations to be taken by forestry to protect water quality. The Swedish Forest Agency distributes grants to promote biodiversity and aquatic environments in the forest and must implement measures in accordance with the water authorities' action programme to reduce the negative impact of forestry on water bodies.

The Swedish Environmental Protection Agency has overall responsibility for nature and environmental protection issues, and works on issues relating to wetlands, green infrastructure and nature-based solutions. The Swedish Environmental Protection Agency is responsible for the central regulatory guidance on land drainage.

The Swedish Transport Administration plans infrastructure and plans and implements measures to reduce the environmental impact of the existing transport infrastructure. The national plan for the transport system 2018–2029[83] includes significant funding for measures to address issues related to water protection and stormwater management, among others.

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83) www.trafikverket.se

At international level

Sweden shall implement what is required to meet the UN's sustainable development agenda, Agenda 2030. The Swedish environmental quality objectives are considered to constitute the environmental part of the agenda. In addition, Sweden has joined a number of global UN conventions related to water resources.

Regional environmental conventions for the Baltic Sea and the North Sea. Generates requirements for land and water use to reduce the burden on marine areas. For the management of the Torne River, a river on the border with Finland, there is a special border river commission to promote cooperation on water and fisheries issues between the countries. There has also been a border cooperation agreement since 1929 for the cross-border watercourses between Sweden and Norway, in which the largest cooperation areas are the Enningdal River and Klarälven-Trysilelva.

The European Council sets out the focus of the policy. The Commission coordinates EU guidance (CIS) and proposes laws/directives that are then adopted by the Parliament and the Council. The European Court of Justice is responsible for interpreting EU law.


Photo: Jon Flobrant

Measures for better water management

Following on from the problems described above, we provide the following list of different measures and recommendations that we believe would help develop a strategy for sustainable water resource management in order to meet future challenges and needs.

Physical measures

Nature-based solutions (NbS)

With a changing climate, more climate adaptation measures will be needed both to manage surplus water and to address water scarcity. Nature-based solutions (NbS) can help regulate water by slowing runoff and evening out flows. Through the introduction of nature-based solutions, ecosystem services can be protected, strengthened and restored for the benefit of society and nature. Parks, green areas and other green spaces can both retain water to reduce the load on sewage systems and infiltrate water.
Traditional technical solutions (grey solutions) that have long been considered the best option for addressing climate-related challenges do not go far enough. In many cases, a technical solution can be both necessary and effective, but an unconsidered choice of a grey solution will miss the opportunity to solve several important societal problems in a single solution, which is something that nature-based solutions can provide.
Nature-based solutions can play a key role in addressing the interlinked climate and biodiversity crises, while contributing to transformative and sustainable development[84].
Nature-based solutions can be more cost-effective than traditional technologies and a combination of "grey" and "blue-green" infrastructure are worthy of consideration.

84) Nature-based solutions (diva-portal.org)

Restoring lakes, watercourses and wetlands

The UN has declared 2021 – 2030 to be the decade of "ecological restoration" with the aim of focusing on food security, water availability and biodiversity. Restoration and rehabilitation of valuable environments, such as lakes, watercourses and wetlands, is a measure to ensure long-term biodiversity and to contribute to the sustainable use of our waters. Restoration should be viewed from a catchment area perspective, but local efforts can be of great value[85].

Lakes as reservoirs to ensure water supply

One of the most effective measures to reduce the risk of water scarcity for an area's water is to use lakes as reservoirs in order to ensure the water supply in the water supply point. This is one of the conclusions of the SMHI Government commission[86]. Other measures may have a localised effect but not an adequate effect to affect water flows on a larger scale.

Environmental adaptation of hydropower

A wide range of measures can be considered for both existing and new hydropower plants in order to reduce their ecological impact. These can either mitigate potential impacts before they occur or restore damage that has already occurred. Environmental adaptation is in progress and shall be implemented over the next 20 years. It is important that the environmental adaptation takes place from a holistic perspective, taking into account other forms of impact and climate change.

Measures at municipal level

Municipalities and water utilities need to plan preventive measures in order to meet both current and future situations of too much and too little water. This may involve increasing knowledge of local conditions and vulnerabilities, drawing up contingency plans for extreme situations and increasing redundancy in the water supply in order to address situations of water scarcity. A range of measures can be implemented at municipal level in order to ensure access to drinking water. These include measures such as artificial groundwater formation, induced groundwater formation, increased surface and groundwater abstraction, desalination, information campaigns to encourage users to save water, improved wastewater treatment for use in irrigation and other purposes. [87]

Cooperation and collaboration

Water is a shared responsibility. It is important to have a common starting point and basis for the necessary cooperation between different types of activities, as well as local, regional and central actors. Collaboration is especially important when several actors share water resources.

Inter-municipal cooperation and collaboration across county borders is important for a robust water supply, especially if problems arise, such as water scarcity. There may also be a need for regional solutions, such as for the supply of drinking water.

Agricultural measures

There are also a number of measures that can be taken in agriculture in order to improve water management. Examples include regulated dams, irrigation reservoirs and improved irrigation technology[88].

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Measures to strengthen water management

Using the right quality of water and in moderate quantities for a specific purpose reduces water and energy consumption and the demands on water as a resource. It is important to improve the efficiency of water production and distribution as well as the use of water itself. When it comes to the former, leakage from water supply systems, for example, needs to be minimised. According to Swedish Water, leakage in municipal drinking water systems is equivalent to 15 per cent of the amount of water abstracted. This is slightly lower than the average value for EU Member States, which is around 23 per cent[89]. In addition to improving the efficiency of production and distribution, the efficiency of usage can be improved through, for example:

Industry's water consumption

1. technological innovations to reduce water consumption,
2. re-use of process water

At household level

1. rainwater collection,
2. small-scale desalination
3. vacuum toilets and other water-saving technologies

Hospitality/tourism

1. water-efficient technologies in the hotel industry
2. brackish water for pools and toilets

Other measures to improve water management can include increasing water availability through storage or re-use. This can be achieved, for example, by raising water levels in sunken lakes or by collecting and using stormwater for different purposes. Upstream water storage in undeveloped or sparsely populated areas can ensure water supply and reduce the risk of flooding in more densely populated areas downstream[90].

89) http://www.eureau.org/resources/publications/1460-eureau-data-report-2017-1/file

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Appendix 1 Dialogue on sustainable water resource management

Purpose of the dialogue

The overall purpose of the dialogue has been to highlight and analyse how Sweden manages its water resources based on a holistic perspective or in a so-called nexus, a coherent and sustainable management of the water resource that meets the needs of energy, households, industries, green industries and nature's ecosystems, taking into account increasing challenges due to population changes and climate change. The starting point is that current water management with its focus on water quality, drinking water supply and water bodies needs to be broadened to clearly include quantity and society's overall need for water based on a catchment area perspective.

More specifically, the purpose of the dialogue is to:

1. illustrate what we call a framework for sustainable water resource management. The framework consists of responsible authorities, operators, the general public, regulatory frameworks, knowledge bases, forms of work and collaboration, etc.,
2. highlight the opportunities, needs and shortcomings of the framework,
3. find ways to build trust and understanding between different actors,
4. clarify what knowledge is needed about how the water resource is used nationally and in catchment areas, economically, socially and environmentally.

Participation and implementation

Around thirty people participated in the dialogue, representing twenty-five different organisations – state and regional authorities, regions and municipalities, universities and research centres, drinking water producers and industry. The objective was to host a broad representation without the group growing too large. Participants were selected from SwAM's contact network. The participant numbers in the dialogue increased slightly over time following suggestions from participants.

Throughout, the dialogue was conducted under the so-called Chatham House Rules, which means that participants are free to use information from the dialogue, but that it is the views that are of interest and not who said what. The aim was to create conditions for an open and unbiased dialogue.

Five dialogue meetings were held, starting in June 2019 and ending in October 2020. During the pandemic, a large part of the dialogue could not take place via physical meetings but was instead held digitally. Such a context has been a limitation. It is not easy to conduct an open dialogue and establish new relationships digitally. Physical meetings are usually more effective and provide better conditions for creating inclusion, which benefits problem solving and reduces the risk of misunderstandings. Despite this, we felt that the digital meetings worked relatively well. The technology worked well and the participants demonstrated good digital meeting discipline.

Dialogue I	Dialogue II	Dialogue III	Dialogue IV
›› Policy objectives and sustainable water resource management	›› Water balance, water abstraction and water usage	›› Industrial water management	›› Ecosystem needs
›› Sweden's water resource management	›› Sweden's water resources	›› Forestry industry needs	›› Collaborative processes
›› Future demands and how to create change?	›› Agricultural water management	›› Forestry needs	›› Social economy
›› The groundwater perspective	›› Urban/municipal needs	›› Regional water supply	›› National strategy for a developed framework
		›› Priority development areas	

Dialogue 0 ›› Problem formulation and analysis in collaboration

Initial dialogue

The purpose of the initial dialogue (Dialogue 0) was to gauge interest in the issue and reflect on the concept of sustainable water resource management based on the perspectives of sustainability, distribution and change. Examples of questions discussed were: What is meant by sustainable water resource management?

What are the main constraints and enablers in current water resource management?

Is the division of responsibilities between state-municipality-individual appropriate for sustainable water resource management?

Is the catchment area a practical management object?

Does the water management process lead to sustainable solutions, i.e. to the "right" balance between the three dimensions of sustainability?

How can the "sustainability and resource perspective" be strengthened in the process?

Dialogue I, II, III and IV

In subsequent dialogues, we raised the concept of sustainable water resource management for discussion as a way to identify constraints, challenges and opportunities in current water management and how these can be addressed in the future work.

As a way to organise the continued dialogue, we introduced a framework for sustainable water resource management. Our framework included responsible authorities, operators, the general public, regulatory frameworks, knowledge bases, forms of work and collaboration, i.e. everything that together contributes to water resource management. We defined seven development areas, four of which were identified by the participants as the most important to focus the dialogue on: Regulation and governance; Working methods; Knowledge base; and, Socio-economics.

Figure. Identified development areas for sustainable water resource management. The participants in the dialogue were asked to describe which areas they considered most important. The figures show the results of the exercise.

The dialogue covered a total of 18 different themes. Our impressions, thoughts and reflections from these different themes can mainly be categorised under four headings: Management, governance and regulation; Working methods and perspectives; Knowledge, conditions and understanding; and, Water supply and water needs.

Management, governance and regulation

Water management is perceived as too detailed and lacking in transparency. All and parts of water management and its regulation have been investigated on several occasions since preparations for implementation of the Water Framework Directive began at the end of the 1990s. This involves around thirty investigations. Some changes have taken place, but many issues recur. This creates uncertainty within the administration and makes it unclear to outsiders, which has an effect on implementation.

Management

The management of our water resources from national to local level is complex, consisting of many levels and many actors. Management has to relate to the global Sustainable Development Goals (Agenda 2030), a wide range of global and regional conventions, EU-led directives, strategies and objectives, national environmental objectives, regulations, strategies, objectives and action plans, regional strategies, management plans and action programmes, as well as to local needs and conditions.

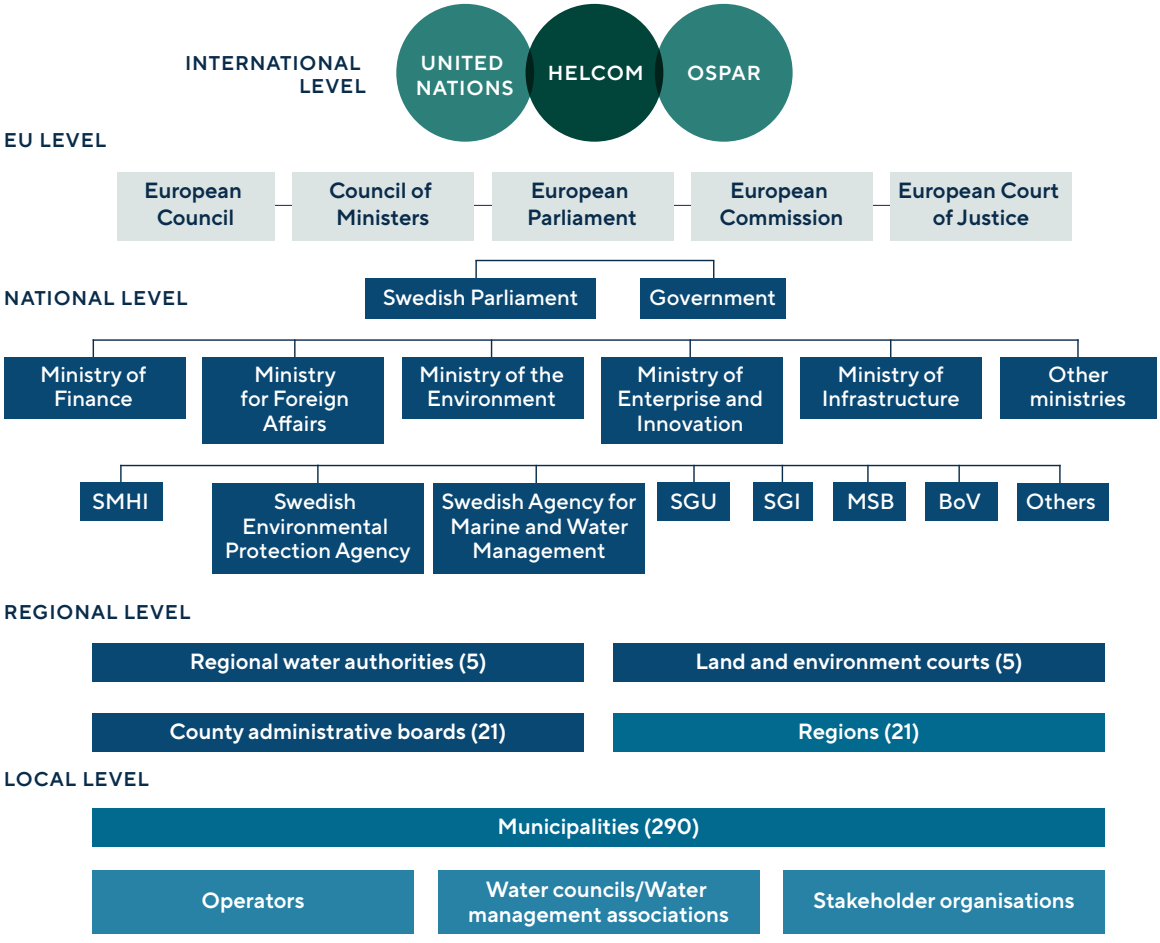

Figure. Water resource management from international to local level.

Challenges, needs and issues vary between organisational levels but issues such as climate change, demographic changes, energy supply, biodiversity and urbanisation arise at all levels.
Many authorities and ministries are involved, which requires cross-sectoral cooperation and coordination at different levels.

Regulation and governance

The management of our water resources concerns many policy areas and requires coordinated and coherent policies. A wide range of conventions, strategies and laws provide guidance and direction, at EU, national as well as global levels:

1. Agenda 2030
2. Global conventions
3. Regional conventions such as the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area.
4. EU directives such as the Water Framework Directive, Urban Waste Water Treatment Directive, Floods Directive, Nature Conservation Directive, etc.
5. Common Agricultural Policy
6. Circular and bio-based economy
7. Food strategy
8. Regional development strategy
9. Energy agreement
10. Sweden's environmental quality objectives
11. Cultural environmental objectives
12. Climate Act
13. Rural policy objectives
14. Environmental Code and associated ordinances
15. The Planning and Building Act
16. The Law on Public Water Services

The Environmental Code with the Water Administration Regulation implements the Water Framework Directive in Sweden and formulates requirements for the water quality to be achieved. The objective is for all water bodies to achieve what is known in water management as good status, unless there are justified socio-economic reasons for setting a different target level. Good status means an environmental state with minor deviations from a state unaffected by humans. In cases where water abstraction and other demands on the water resource risk affecting water quality, the requirement for good status constitutes a limitation.

The Water Administration Regulation permits certain exceptions but does not set out how to prioritise between different societal interests. The requirement for good status is a challenge in urban planning. The requirement applies per water body, which means that it can be difficult to implement a measure that risks worsening the status of one water body but which would nevertheless create an overall positive benefit by improving the status of several others.

Chapter 11 of the Environmental Code regulates so-called water operations, which involve constructing or removing installations in water, supplying or diverting water or carrying out other measures intended to change the water conditions in water or on land. Abstraction of surface or groundwater is a water operation and usually requires a permit (water judgement) from the Land and Environmental Court.

The Planning and Building Act is essentially urban planning legislation with trade-offs regarding land use. The municipalities have a "planning monopoly" and, according to PBL, must plan land and water and then make an overall fitness-for-purpose assessment of all relevant interests – the law does not prioritise any interest in advance. The Planning and Building Act (PBL) is an exploitation law, not a protection law.

The Public Water Services Act (LAV) aims to ensure water supply and sewerage services in larger contexts if it is necessary for the protection of human health and/or the environment. According to the LAV, water supply is defined as the provision of water for household purposes. A wider interpretation, water supply from a landscape perspective, could support sustainable water resource management.

Legislation needs to be developed to support sustainable water resource management in order to reduce the risk of flooding and drought. All types of water operations subject to licensing need to have modern environmental conditions, not just those producing hydropower electricity (Chapter 11, § 27 of the Environmental Code). Knowledge on water abstractions also needs to be improved.

Working methods and perspectives

Water is a societal issue and not a sectoral issue. Sustainable water resource management affects many different interests and requires trade-offs between different societal objectives. The implementation of sustainable water resource management and related water legislation needs to be based on the best available knowledge and carried out in a way that does not impede or prevent the achievement of other societal objectives. Collaboration therefore needs to involve relevant authorities and activities at local, regional and national levels.

The planning of land and water use needs to be strengthened. Planning needs to take place on a catchment area basis in order to manage different conditions and needs upstream and downstream.

The municipalities plan land and water use according to the Planning and Building Act. To achieve planning that ensures the needs of society and nature on a catchment area basis requires inter-municipal collaboration. The objectives for collaboration need to be supported by governmental requirements, objectives and strategies. In cases where governmental requirements encroach on property rights and result in claims for compensation, the government should contribute.

The state, through the land and environmental courts, issues permits for the use of the water resources – previously under the Water Act, now under the Environmental Code. Permits are granted on a site-by-site basis, but not from an overall water planning perspective. Trade-offs for sustainable water resource management need to be strengthened for the natural environment, urban development and other uses.

Knowledge and methods are available for managing heavy torrential rainfall over urban areas and high flows, and more and more is also being done, especially in new construction since the rules of the Planning and Building Act have been tightened. However, the technical and legal problems are greatest in existing buildings, which will continue to dominate the urban areas for several hundred years to come. Densification in areas with existing buildings to accommodate population growth, without the need to use undeveloped land, can exacerbate problems with flooding.

Catchment-wide trade-offs will need to be made in order to enable nature-based solutions that can both retain and purify water. These should address different types of benefits and costs such as social, economic and ecological, using a so-called sustainability analysis, for example.

Working methods

Sustainable water resource management cannot rely solely on laws and regulations. The parties that affect and are affected need to understand what is required, which demands dialogue, education, knowledge and a well-structured and managed collaborative process that takes into account national, regional and local needs and conditions. Involve all parties affected, representatives of the general public, activities, authorities, non-profit organisations and others in the management of land and water.
One example of a collaborative process is the recurring work on a national transport plan – a nationally controlled collaborative process for which the Swedish Transport Administration is responsible. The planning process links needs at national, regional and, to some extent, local levels. The planning process applies the so-called four-step principle:

1. Rethink – measures to reduce water consumption.
2. Optimise – measures for more efficient water use
3. Rebuild – measures for more efficient water production
4. Build new – measures to utilise new water resources

Establishment and participation take place locally and regionally.

Collaboration

Sustainable water resource management affects many different interests and requires trade-offs between different societal objectives. The implementation of sustainable water resource management and related water legislation needs to be based on the best available knowledge and carried out in a way so that it does not impede or prevent the achievement of other societal objectives. Collaboration therefore needs to involve relevant authorities and activities at local, regional and national levels.
The process of developing the national transport plan is an example of a structured and controlled collaboration process that links objectives and needs at national, regional and, to some extent, local levels.

Within the transport sector, there is one strong central national actor that provides resources for maintenance and development with a budget that supports the implementation of the plan. The process consists of various elements, several of which could be applied to water resource management: the four-step principle, landscape perspective, studies of selecting measures.

A similar process could perhaps be applied within water resource management. However, there is no national plan in place for water resource management. The closest to a plan are the five district water management plans, but these primarily have a water quality perspective and no direct budgetary link. It can therefore be difficult to try to apply the process to water resource management. Are there challenges in how local-regional participation is achieved? How are local-regional needs and priorities balanced against national objectives and commitments?

Risk management

Reducing the risks of too much or too little water often requires measures to be taken upstream. This means that the parties affected by the measures are not among those who would otherwise be at risk of flooding or water scarcity. Different types of land measures are usually required to retain water in order to reduce the risk of flooding downstream at times of high water levels, or to store water in order to reduce the risk of drought at times of low water levels. Changes in legislation, the facility to pay encroachment compensation to landowners, and a structured cooperation process at catchment area level are needed here.

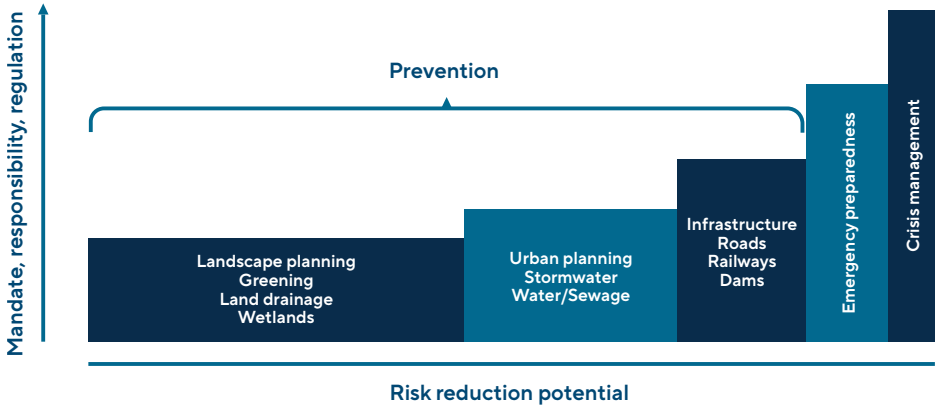

Figure. The diagram illustrates the possibilities to prevent risks from too much and too little water, and prevention is better from all perspectives compared to crisis management[91].

Conclusions and reflections from the dialogue

The dialogue has been broad and covered many issues and themes. Engagement has been high, which reflects the importance and significance of the issues. The starting point for the approach has been that the water resource and the utilisation perspective need to be more clearly integrated into current water management so that the societal perspective becomes visible. Our understanding is that there is broad support for this from many people with different perspectives and interests in the issue.

As previously mentioned, the EU's Common Implementation Strategy for guidance in water management has adopted the OECD's ten principles for integrated water resource management (IWRM) as guidance for the implementation of the Water Framework Directive. The principles emphasise the water resource and utilisation perspective as two central themes for management. The dialogue implicitly addressed most of the ten principles and highlighted shortcomings in Swedish water resource management in relation to several of them:

1. Integration of environmental objectives combining quality objectives as well as ecological objectives and quantity objectives in order to protect valuable aquatic ecosystems and ensure overall good status for other waters,
2. **Integration of all water resources in lakes, watercourses, wetlands and coastal ecosystems at catchment area level.**
3. **Integration of all water use, functions and values into a common policy framework.**

91) Based on the idea of WMO/GWP, 2018 and Aspegren et al. 2019)

4. Integration of different disciplines, analyses and expertise in order to assess the impact and its effects on water resources, and to identify measures to achieve the goals of the Directive in the most cost-effective way.
5. **Integration of water legislation into a common and coherent framework.**
6. **Integration of all essential aspects of management and ecology relevant to sustainable planning at catchment area level.**
7. **Integration of a broad spectrum of measures, including pricing and economic and financial instruments, into a common management strategy in order to achieve the environmental objectives of the Directive.**
8. **Integration of relevant stakeholders and civil society in decision-making by promoting transparency and by making information available to the public by providing opportunities for stakeholders to participate in the planning process for catchment areas.**
9. **Integration between and within different levels of decision-making (national-regional-local) that affect the water resource or the water quality**
10. Integration of management in international catchment areas.

The perceived shortcomings linked to the principles highlighted in bold above can be interpreted as an incomplete implementation of the Water Framework Directive, or perhaps rather a lack of integration of the Water Framework Directive into policy, management and legislation.

Water is a societal issue

Water affects virtually every aspect of society. Access to clean water is a prerequisite for the development of society. The aquatic ecosystems clearly need to be restored, protected and preserved in order to ensure biodiversity and essential ecosystem services. There is broad agreement on this. In the light of the analyses by the water authorities, which state that over 60 per cent of water bodies are at risk of not achieving the agreed upon standards, the question becomes:

1. Are the water bodies significant and delimited in accordance with the purpose of the Directive?
2. Is the assessment of the status of the water bodies quality assured?
3. How should the remedial work be prioritised?
4. How does water availability affect other societal objectives and needs such as agriculture and energy production?
5. What will be the total cost to society of achieving established environmental quality standards and how will these be distributed?

Clear target vision and prioritisation

A clear description is needed of what is to be achieved. This is not conveyed by water management with its diversity of water bodies, environmental quality standards and quality factors. The definition of good ecological status means that the values of different quality factors may only deviate slightly from the values that apply to unaffected conditions. What does the term unaffected conditions then mean in a landscape that has been affected by human activities over a long period of time?

A coherent policy

Water resource policy is linked to, and dependent on, many other policy areas besides environmental policy, and vice versa. Water resource policy needs to be coordinated with other policy areas. Obvious areas are policies in agriculture and food, forestry, energy production and other basic industries, cultural environment, transport and regional development. Political participation and presence are therefore prerequisites for coordination. One way to achieve this could be to raise decisions on management plans and action programmes in water management to government or parliamentary level, as proposed in several investigations.

The dialogue demonstrated that the water resource issue is a societal issue that can be viewed from many different perspectives and attracts widespread interest. Reducing the risks of water scarcity and flooding is a planning issue, which means that the water resource issue needs to be managed sustainably over time and coordinated geographically, mainly by catchment area, and sectorally in order to collectively manage the whole range of different water needs.

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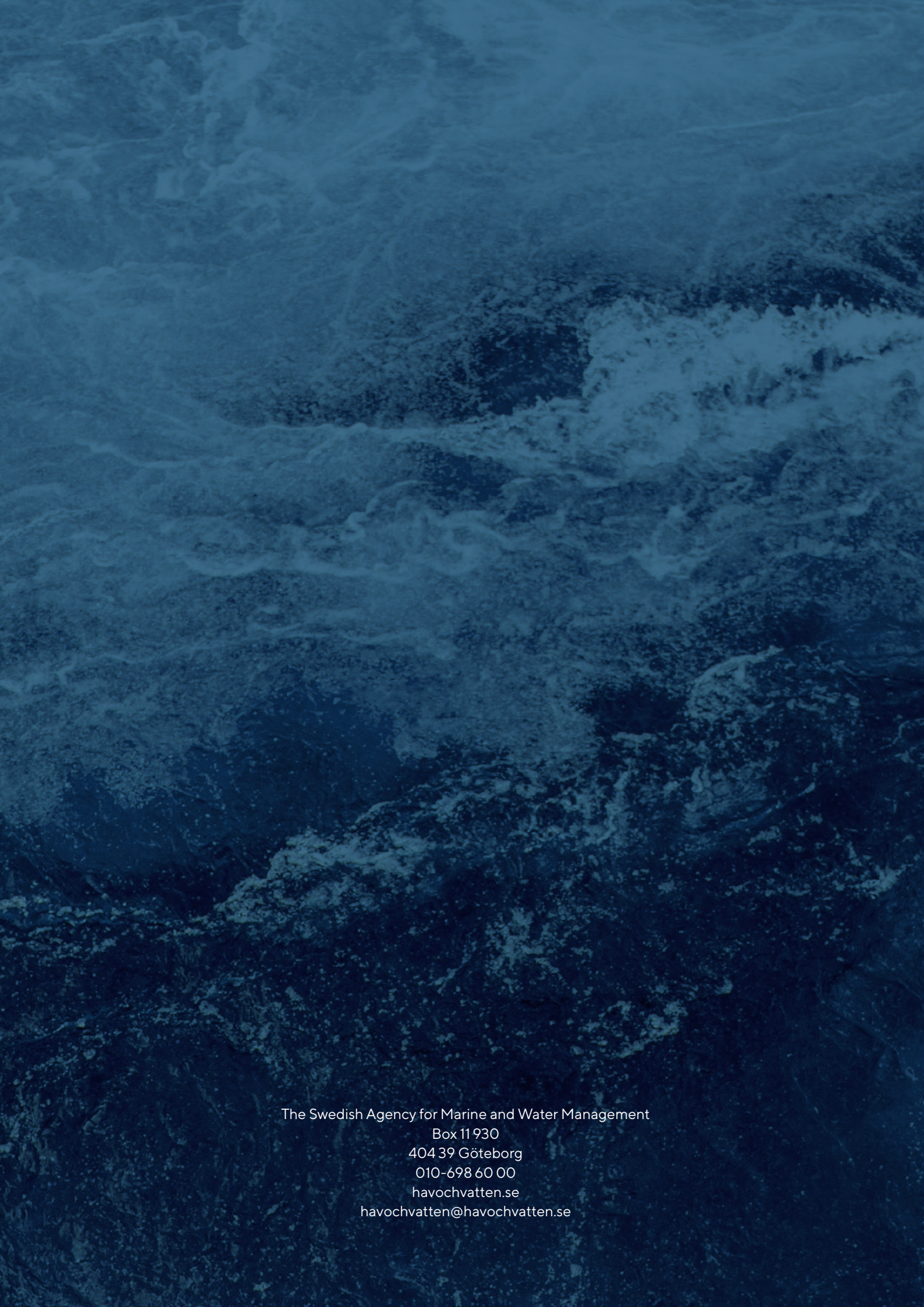

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