Briefing Note

Climate change and water services: adapting to the consequences

Summary

Climate change will directly and significantly affect water service providers in most parts of Europe, resulting in more frequent or intense periods of drought, heat waves or rain storms, and in more places.

We will all need to be more proactive to prepare for the growing scale of the fallout. This was evident with the intense drought during the spring and summer of 2018 when it became clear that the water sector must get involved in local/regional/national crisis management.

Our sectors' response to climate change should encompass both mitigation (reducing the impact of water services) and adaptation (become resilient to its effects) measures.

This briefing note focuses on how climate change will impact on our sector, and the ways and means to adapt to these changes based on our current knowledge.

Climate change will have many direct and indirect effects on the quality and quantity of available water and will therefore impact on water services. It is critical that water operators analyse their individual situation comprehensively to identify suitable adaptation measures and integrate the findings into their planning and decision-making processes.

Water service providers are not the only ones who should be reacting. Policy makers need to be made aware of and support favourable framework conditions, for example: putting in place clear governance structures, prioritising drinking water supply before all other uses, granting priority to public water supply in the case of uncertain power supply and developing holistic strategies to prevent floods and prevent Combined Sewer Overflows.

1. Introduction

Climate change and its impacts have been the focus of public attention for many years. Political efforts to mitigate climate change have received new impetus with the European Commission preparing its Green Deal. It will propose a 50-55% reduction in greenhouse gas emissions by 2030 with the objective of achieving net zero emissions by 2050. A number of Member States and regions have already taken similar commitments with Finland aiming for zero emissions by 2035, Scotland by 2045, and Denmark, France, Ireland, Portugal and the United Kingdom by 2050.

Likewise, water operators may make pledges towards climate neutrality. For example, English water operators committed to become fully carbon neutral by 2030.

In spite of these commitments, climate change will continue in the foreseeable future. According to present knowledge, its impacts will vary significantly from one European region to another. It will directly and significantly affect water service providers in many parts of Europe, i.e. in terms of the quality and quantity of raw water availability as well as how waste water infrastructure operates. The response of water services to climate change should encompass both mitigation (reducing the impact of water services) and adaptation (become resilient to the effects) measures.

Given that water service providers are used to long-term planning and investment periods as well as having the know-how to cope with changing parameters, they should - in cooperation with researchers, politicians and other stakeholders - be expected to succeed in adapting to the consequences of climate change.

This briefing note focuses on the impact of climate change, and on how the European water sector can adapt to these changes. The paper addresses the topics that are relevant for the sector to consider in broad discussions related to adaptation to climate change.

The paper provides a short overview of major climate change mitigation measures implemented by water service providers.

2. Climate change in Europe

The general trend across Europe is that annual average temperatures are rising, resulting in warmer and drier summers and milder and wetter winters. As seasonal and spatial climate variability increases, the reliability of projections on future water management parameters decreases. Extreme weather events such as intense storms, rain storms and extremely dry periods are generally more likely to become more frequent before the end of the 21st century according to most studies.

However, regional projections for concrete quantitative climate parameters are still uncertain, and can be made only within relatively wide boundaries. The degree of uncertainty about the effects of climate change is higher still if we want to determine the changes of parameters such as groundwater recharge or runoff regimes in river catchments on the basis of various climate factors (e.g. precipitation, temperature, evaporation).

Climate change may also affect some of the familiar, fixed parameters that serve as a basis for planning and investment decisions for safe and efficient water operations. These parameters are derived from long-term time observations that describe the availability of resources. Often, the hydrological conditions have ceased to be a reliable basis for helping to assess future conditions.

Increasing climate variability creates a wider range of potential weather conditions. This requires precise analyses and monitoring of all climate-related conditions relevant for water service providers so that they can respond to emerging trends. Long-term operating and investment decisions should take into account the expected range of climate changes which may impact the operation of facilities and networks.

3. Impacts on water services

Climate change may result in more frequent or intense occurrences of phenomena such as intense periods of drought, heat waves or rainstorms, and in more places. The effects of these are not vague unknowns for water utilities. They have mostly been able to cope with them thus far but they will need to be more proactive so as to be ready to deal with climate change. This was already the case in 2017 with the intense drought in parts of Europe, but especially during the spring and summer of 2018, when many parts of the continent suffered from an extended period of unusually hot weather and drought. It became clear that the water sector will have to get increasingly involved in local/regional/national crisis management.

3.1 Quantitative and qualitative aspects of changed water availability

While annual precipitation and total runoffs increases may improve the water supply situation in some regions, the drinking water sector will nevertheless have to adapt to a seasonally or intermittently reduced availability of water. Whether or not a permanent or temporary fall in availability will lead to a critical situation for a water supply system depends on a multitude of local factors such as:

~ the non-existence of alternative water sources and sufficiently flexible local abstraction facilities allowing utilities to respond to a (temporary) loss of individual abstraction types/catchment areas;

~ the existence of competing water uses and their increasing significance, if applicable (especially agricultural irrigation); and

~ higher peak demands for drinking water due to increased watering of private gardens and pool fillings.

The waste water side is similarly exposed to these changes. It will have to adapt to:

- the increasing number and intensity of heavy rainfall events putting extreme stress on urban drainage systems and waste water treatment;
- the effect of droughts reducing the dilution in receiving water bodies of waste water treatment plant (WWTP) effluents.

These are the many possible consequences of climate change on the quantitative availability of raw water resources for drinking water production or the qualitative status of water resources.

Groundwater

- Reduced groundwater recharge, either permanently or seasonally, leads to a corresponding lowering of the water level. This will be particularly felt in regions where (seasonally) decreased groundwater recharge affects comparatively small groundwater systems, which are less capable of buffering fluctuations in precipitation. Springs fed by small or near-surface aquifers are especially sensitive to changes in water availability.
- In contrast, in regions where groundwater recharge takes place almost exclusively during winter and where winters are getting wetter, average groundwater levels are expected to rise. This may cause water logging and damage to buildings, especially when increasing recharge is accompanied by a lower water demand.
- Changes in water resource availability may also result in changes to groundwater quality, e.g. the non-dilution of contaminated groundwater may lead to higher pollutant concentrations in the raw water.
- Lower aquifer pressure levels caused by lowered groundwater levels will lead to deep-well pump cavitation problems and may cause wells to run dry in extreme cases.
- In coastal regions, the expected sea-level rise may accelerate salt water intrusion into coastal aquifers. This is usually due to the over-abstraction of coastal aquifers. Seasonal tourism is a major driver for this situation.
- Permanently improved water resource availability is expected for regions with increasing groundwater recharges and larger groundwater resources.

Lakes and reservoirs

- Seasonal and intermittent drops in lakes and reservoir level will generally reduce raw water availability during peak demand times.
- This may result in lower depths of the storage volumes suitable for raw water withdrawal, a smaller portion of cold deep water (hypolimnion) and in decreasing water pressures levels at withdrawal points. Beyond this, the capacities to buffer polluted inflows and water withdrawal control options may be compromised.

- Rain storms may adversely affect raw water quality as they may cause erosive runoffs and an increase in overflows from separate and combined sewerage systems, causing increased amounts of sediment- and particle-bound contaminants and microorganisms.
- Climatic changes will more severely affect the quality of small and shallow waters and waters with a higher trophic level than that of deep and oligotrophic waters.

Rivers

- The risk of flooding increases with the frequency of storms. Floods may adversely affect groundwater quality and mobilise dangerous substances e.g. from industrial brownfields. Extremely high water levels may submerge bank filtration systems and thus directly pollute raw water used for drinking water abstraction.
- Increased heavy rains and storm events overloading combined sewerage systems, which drain both waste water and storm water, will lead to more combined sewer overflows and/or sewer flooding. This has a negative impact on surface water quality through increased inputs of sediment- and particle-bound contaminants, diluted contaminants and microorganisms. As a consequence, ecosystems and raw water quality may be negatively affected.
- Overloaded combined sewers or rainwater pipes might lead to local flooding if free discharge is hindered by high surface water levels. This is especially the case after long periods of rain, which are expected to occur more often during winter in certain regions.
- More diluted influent waste water from combined sewerage systems can have a negative impact on efficient waste water treatment in combination with longer lasting periods of rain.
- In addition, when combined sewer overflows (CSO's) occur after dry periods, their environmental impacts are more severe as there is less water in the receiving waters and first flush events might be intensive, increasing the concentration of pollution events.
- During extremely low flows, water withdrawals from rivers might need to be reduced or even stopped.
- During dry periods, less dilution of the WWTP effluent discharged in the receiving surface water can have a negative impact on surface water quality and therefore additional treatment in the WWTP might be required before water can be discharged. This impact is increased through higher water temperatures (less dissolved oxygen).
- Industry and agriculture effluents can affect raw water quality. This is relevant also when river water is used for artificial groundwater recharge or bank filtration.
- Storms, floods and persisting periods of drought may interfere with utility

operation and, in exceptional cases, result in a temporary water supply cut-off.

Seas

~ Rising sea levels may lead to the intrusion of saline water in sewers which may deteriorate biological treatments in waste water plants.

~ Many WWTP and sewage pumping stations are located on low lying coastal areas and could be inundated and rendered useless through the impact of sea levels rising.

3.2 Quantitative and qualitative aspects of rising air and water temperatures

Drinking Water

~ Higher air temperatures increase the vertical temperature gradient in lakes and reservoirs. Thermal stratification tends to become more stable; full circulation - required for the renewal and oxygen supply of the hypolimnion, which is generally crucial for raw water abstraction - occurs more rarely, is shorter and may even stay away for good in isolated cases. Moreover, prolonged periods of heat may result in deeper epilimnion strata, thus reducing the depth of the hypolimnion. Increasingly insufficient deep mixing with ensuing deep water replenishment has already been observed in winter.

~ Higher temperatures generally accelerate biological and chemical processes in water bodies. This tends to adversely affect raw water quality; the extent of the impact however also depends on other parameters, such as the availability of nutrients and oxygen. These may foster the growth of algae, for instance, so that algal blooms and a concurrent development of odours and tastes as well as the release of bacterial exo- and endotoxins may ensue. Another consequence may be delayed phyto- and zoo-plankton growth, resulting in the degeneration of food chains within aquatic communities.

~ Higher air and soil temperatures may also lead to higher drinking water temperatures in distribution networks. Whether higher temperatures increase the risk of microbial growth and contamination depends very much on the general condition and operation of the supply system. In networks with a given tendency towards microbial recontamination, this tendency will be reinforced through higher temperatures.

~ Higher air and water temperatures tend to favour the proliferation of a variety of waterborne pathogens. Impairment of drinking water is possible only in exceptional cases. In general, the monitoring and treatment of raw waters potentially at risk (surface water, near-surface groundwater and spring water) already focuses on the presence of pathogens.

Waste water

- Higher temperatures will improve the biological treatment efficiency, but might increase energy demand for aeration. Eventually, warmer effluent might have a negative impact on the receiving water bodies in cooler climatic zones.
- Higher temperatures may imply problems in the sewer systems due to the production of hydrogen sulphide (H_2S), increasing corrosion and odour issues.

3.3 Indirect consequences for water bodies and water services

- Higher soil temperatures promote conversion and mineralisation processes in soils and, consequently, the pollution of seepage water. These processes depend on sufficient soil moisture. The trend towards drier summers increases seasonal topsoil desiccation, which inhibits mineralisation processes. The conversion and displacement of the accumulating substances is delayed until infiltration of the vadose zone occurs in autumn, which may result in a considerable mobilisation of substances (e.g. nitrate) and subsequent pollution of seepage water.
- Intensive agriculture is coupled with an increased demand for irrigation, fertiliser and pesticide use, triggered by the extension of the growing period, and often decreasing precipitation during that period.
- Extreme weather events like rain storms, hailstorms or droughts may lead to crop failures or even ruin the entire standing growth, causing plants not to absorb fertilisers and/or the fertilisers to remain in the plant residues, which may result in massive nitrate pollution of groundwater.
- Conflicting demands for the use of locally or regionally available water resources may occur when water resources fail to satisfy the demand (i.e. water suppliers, households, farmers, businesses and industries) in a region.
- Changing precipitation patterns, especially longer periods of drought, will increase the demand for various water reuse applications including in farmland irrigation and ground water recharge. Regions not applying treated urban waste water reuse today, may have to implement such solutions in the future. This may trigger investments in WWTP to provide the water in the right quality or may require legislative or other actions from local governments to allow the reuse of treated waste water.
- Peak demand increases, for example during the dry 2003 and 2018 summers, demonstrated that water consumption increases during dry and hot periods. As a result, the gap between average and peak water demands grows. The situation is exacerbated in regions with decreasing average water demand caused by e.g. a population decrease, a change in industrial consumption etc. Under such circumstances water suppliers face new challenges for the design, construction, and operation of water supply systems.

- Tourism benefits from good environmental conditions. The quality of bathing waters can be negatively affected by CSO's during heavy rains.
- As extreme weather and flood events are likely to become more frequent and intensive, dam and reservoir management will have to focus more on flood protection, which in turn may result in reduced storage capacities for raw water abstraction.

4. Adaptation options for water services

In order to identify suitable adaptation measures, water operators should analyse their individual situation comprehensively, focusing on the following questions:

- Which impacts and consequences will affect my system?
- Which assets and processes of my system are particularly sensitive to the expected impacts?
- Which adaptation options do the ongoing operation schemes and the established management tools offer?
- What needs to be considered with regard to future investments?

The continuous integration of the findings thus obtained into all planning and decision-making processes of the operation is crucial.

Options for water suppliers:

Management and protection of water resources

- Trend analyses and drawing up of long-term water availability projections.
- Area-specific adaptation of monitoring networks and programmes enabling staff to knowledgeably assess potential quality changes.
- Integrated water resource management, taking into account aspects of both quality and quantity.
- Securing drinking water supply through official spatial planning and water resources planning and approval procedures.

Abstraction, treatment and network operation

- Redundant abstraction systems allow for a flexible combination of different types of raw water resources and abstraction technologies. This may be achieved by creating networks (developing additional proprietary raw water sources, integrating adjacent local direct supplies, connecting to regional water supply systems).
- Adapting wells and pumping facilities to changing parameters (e.g. permanent or temporary phreatic decline or falling reservoir water levels).

- Adapting water treatment to expected new or changed raw water qualities.
- Adapting disinfection facilities in storage and distribution systems.
- Creating larger storage capacities in water works and networks to ensure that supplies meet growing peak demands.
- Adapting network inspection and flushing schemes.
- Keeping water losses permanently low.

Organisation and management

- Adapting organisational structures and management processes to the expected changes so as to be able to manage risks and crises.

Water demand

- Encouraging water use reduction measures.

Options for urban drainage systems and waste water treatment:

- Conducting a climate change risk analysis and put in place risk management measures.

Combined sewer overflows (CSOs)

- Storm water should be led away from the sewers to open (nature-based) solutions in order to reduce the amount of rainwater in the system
- Separated sewer systems and/or sustainable urban drainage systems (SUDS) in new developments should be implemented as control-at-source measures to reduce or attenuate storm water discharges into piped sewerage or storm water drainage systems.
- In many cases, a separated sewer system will not be possible, due to economic, local and/or technological reasons. For example, if rainwaters are also contaminated (next to roads with heavy traffic), this cannot be considered as a solution. Separate sewer systems could be a solution for new settlements or neighbourhoods.
- Other solutions involve one or a combination of measures like adaptation of the design and dimensioning of the combined sewer system, construction of storage basins for excess flows, decreasing storm water overflows with RTC (real time control), treating overflow water, and implementing enhanced treatment at WWTP. Amongst these, it is worth noting that RTC is key in order to properly address these issues in a proper manner and in real time.
- Solutions that combine grey and green measures (sunken verges, swales, tree pits and water gardens in open spaces and public areas), including natural

retention measures, appear to be more cost-effective in reducing the impact of pluvial flooding after heavy rains. Their use should be considered even in existing urban landscapes.

~ A solution can be to accept, for short periods of time, some storm water on the street. For example, Copenhagen fixed 10cm as the acceptable limit of water on the surface in storm water situations.

~ Urban rivers and streams should be redesigned to remove previously engineered solutions such as concrete channels or culverts and restore these water courses to as close to nature as possible through softening channels, planting etc.

~ Enhanced hydraulic modelling is a valuable tool, especially when adding pollution/quality modules.

~ The increased drainage of storm water in combined or separated sewers may lead to the need for new financial resources from the stakeholders that have impervious areas connected to the public system.

Waste Water Treatment

~ To reduce the impact of effluent temperatures on the receiving water, it might be necessary to cool the effluent before discharge, adding cost and energy needs to the WWTP process. If heat recovery technologies are installed, the heat could be used to heat residential and/or industrial premises.

Water Reuse

~ There is an increasing tendency for multiple uses of water. In the frame of reduced water availability, the use of reclaimed water is a valuable solution, provided there is confidence in the health and environmental safety of reclaimed water.

~ Separately collected and buffered clean storm water can become a valuable source of water to overcome periods of droughts, if buffer tanks are equipped with an adequate steering combined with weather forecast.

5. Mitigation measures

The water sector actively contributes to climate change mitigation by increasing the energy efficiency of processes, generating energy from renewable sources and reducing its carbon footprint.

Waste water treatment plants, once seen as energy-intensive businesses, are more and more considered as sources of for renewable and reusable materials such as reclaimed water, energy, heat and nutrients, including phosphorous. The production of ‘green’ energy through sludge digestion could be improved by promoting local partnerships (solid waste, energy companies, farmers, restauration, households), and removing barriers to innovation.

When planning mitigation measures, the water services sector must take account of the EU's "strategic long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050"[1]. The key objective of the strategy - climate neutrality - demonstrates the scope of the challenge.

6. The governance, regulatory and economic climate change adaptation framework

6.1 Starting points

It is beyond doubt that our climate is changing and that these changes will require substantial adjustments to water utilities' operations. With this in mind, the following starting points can be defined:

~ Case studies indicate that the cost of non-action is higher than that of adapting the drinking water supply and sewerage and/or storm water drainage systems to the new challenges.[2] For example, the final cost after an extreme heavy rainfall event in Copenhagen in 2011 was €1.5 billion. It is generally much more cost-effective to take measures before these problems occur.

~ Climate change adaption is a priority for Europe. Those countries that have experienced more problems with drought and flooding have been forced to develop regulations to adapt to the risks and mitigate the impacts. Southern Europe has dealt with droughts and water scarcity for a long time already and in some parts, the water scarcity is permanent. Now also the northern parts of Europe are increasingly experiencing a lack of precipitation. In Sweden, there have been droughts and water scarcity in the last three summers.

~ There is no one-size-fits-all solution for climate change adaptation. The impacts of climate change on water abstraction, treatment and distribution differ substantially between regions. Impacts and vulnerabilities differ between catchments and even within a supply system. The situation is similar for urban drainage systems and the treatment of waste water.

~ The need for adaptation and the scope for action are always predicated on the prevailing natural conditions, the technical structure of a given system, interaction with other factors, such as societal and economic development, and the concurrent industrial and agricultural water uses. The adaptation capacity of water suppliers and waste water operators is also defined by general legal and political parameters.

[1] European Commission: A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy (2019).
[2] Norwegian governmental report NOU 2015:16. And https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013DC0216&from=EN.

- Water utilities must accept their responsibility in ensuring that drinking water and waste water services become climate change resilient. However, the protection and sustainable management of water resources is an interdisciplinary task, to which the drinking water and waste water sector can contribute but which it cannot accomplish on its own.
- The national organisation of authorities (governance structure) differs from country to country, just as the means and financing of the water sector does. This calls for the use of the subsidiarity principle and transparency and informing consumers how their water services are financed (taxes, tariffs, transfers).

The following chapters present the key questions that need to be addressed and basic conditions that need to be met with a view to achieving a climate resilient water services sector.

6.2 Widening the knowledge base

The development of short-term and long-term projections of precipitation levels and patterns, possibly at regional level, is paramount.

- The success of adaption measures largely depends on the quality and accuracy of climate modelling data and their translation in expected changes in regional weather patterns. Related uncertainties need to be reduced, and the knowledge about the increasing variability of climatic conditions needs to be systematically analysed and considered in the management of resources as well as in the operation and design of drinking water and waste water infrastructures.
- The development of different water uses over time (medium- and long-term) needs to be established, possibly at the level of the river basin in order to ensure that drinking water needs are always covered. A priority list would help all stakeholders to take the necessary precautions.
- It is necessary to provide basic data from supra-regional (climate) models for regional (hydrological) models (e.g. groundwater models) for water resources management purposes.
- As to short-term weather patterns, effective drought observatories can enable water service providers to take reactive water management measures in time. The European Drought Observatory[3] is a good example.
- More research and innovation is needed to identify cost-effective climate change adaptation measures and modelling tools.

6.3 Defining climate change adaptation goals and strategies

Climate change adaptation measures taken by water utilities are one important piece in a much wider puzzle starting from an overall national strategy and breaking down

[3] http://edo.jrc.ec.europa.eu/edov2/php/index.php?id=1000.

into concrete actions taken at the local level. Overall consistency must be ensured through the development of a climate change adaptation plan with short-term, medium-term and long-term measures.

National authorities must be the first to ensure a plan which can guide the local/regional authorities.

The plans should include regular assessments of the effectiveness of the measures already implemented and, more generally, the adequacy of goals and measures in the light of new research results.

6.4 Ensuring clear governance structures

As outlined above, the protection and sustainable management of water resources and the climate resilience of water services is an interdisciplinary task that involves a significant number of stakeholders. The efficiency and effectiveness of adaptation measures largely depends on the quality of national and local governance. Measures should be considered in river basin management plans (RBMP).

~ Based on climate change adaptation plans, the most effective and cost-effective long- and short-term adaptation measures need to be identified taking river basin contexts into account. As a matter of example, the Copenhagen experience shows that it can be four times more expensive to invest in traditional, underground solutions to reduce flood risks, instead of alternative – above ground – solutions[4], while providing similar levels of protection. The latter also shows a better environmental performance[5].

~ From the national to the local level, it must be clearly defined who is responsible for the implementation of agreed actions, who provides the necessary financial means and who reports to whom.

~ A national climate change adaptation plan should include a politically determined level for securing water services. The water use needs should be mapped at the river basin level.

~ Water must be dealt with at an early stage in local urban planning. Climate change adaption must be a vital part of this process (minimum soil permeability, storm water management etc.). Adaptation measures in already existing urban areas are equally important but involve a higher level of complexity and costs.

~ As to storm water, there need to be national standards in regard to the amount of rain which a waste water utility should be able to handle. This is crucial for the technical planning and the financial planning of utilities.

---

[4] Miljøstyrelsen (Danish Environment Agency), 2017: Evaluering af kommunal klimatilpasning (Evaluation of municipal climate adaptation), page 23-24, 28-29.

[5] Life Cycle Assessment of Stormwater Management Systems – Quantification of environmental impacts for decision support – in English:
https://backend.orbit.dtu.dk/ws/portalfiles/portal/181833754/Afhandling_Sarah_Brudler.pdf

- Still on storm water, local decision makers must decide what level of security should be ensured when planning new urban areas and refurbishing existing ones. A politically determined level for security for damages caused by storm water will help the water sector and other stakeholders determine how much precipitation they need to consider when planning their storm water assets in urban areas. This directly affects the necessary volume of the storm water evacuation system and the possible liability of utilities in the event of buildings being damaged by storm water. It is however necessary to take other measures to make cities able to handle a heavy rainfall.
- Actions to be carried out in droughts and water scarcity should be based on planning, through "risk management", and not on emergency measures as "response to crisis". This means focusing on aspects such as the definition of a system of drought indicators, which will help decision making in an objective, progressive and planned manner. At the river basin level, drought planning should be focused on minimising the environmental, economic and social aspects of possible drought situations. This can be done by guaranteeing the availability of water required to ensure health and life of the population, avoiding or minimising the negative effects of droughts on the ecological status of water bodies, as well as on urban water supply and economic activities.
- Even though the river basin level is fundamental, this planning should also be addressed at the local level, focusing on the management of temporary scarcity. Supply systems should establish the definition and description of progressive scenarios of scarcity and the actions foreseen in each, and establish a system of indicators to monitor and control the drought. As an example, the Spanish Law 10/2001 of the National Hydrological Plan, establishes the obligation for public administrations responsible for urban water supply systems that serve a population of at least 20,000 inhabitants, to have an Emergency Plan for droughts, which must take into account the rules and measures provided in the Special Drought Plans of each river basin.
- Authorities should bring together all sectors that could benefit from the use of reclaimed water in order to adopt the most effective solutions at the local level.
- Care should be taken to ensure the long-term functioning (mainly through maintenance) of the adaptation measures.

The most advantageous social-economic measures must be taken, encompassing long-term costs and benefits. Sometimes this means that the RBMP must be considered. In some areas, the best solutions will involve several municipalities working together. To achieve that there must be an interaction between relevant plans and not least the RBMP and the authorities.

6.5 Setting an enabling planning and regulatory framework

In practically all Member States, rules and regulations regarding climate change and the adaptation to its consequences are extremely fragmented with bits and pieces included in many different legal acts at all administrative levels. This creates uncertainties which may hamper the roll-out of measures.

- The national regulatory framework at all levels needs to be assessed and, adapted with a view to ensuring consistency and strong climate change governance.
- It is vital to link responsibility, the possibility to take measures and the financing with the legislative process, the legislation and the implementation.
- All stakeholders must cooperate. Planning authorities should be obliged to share and discuss their plans at annual meetings with relevant groups. Denmark has positive experiences in this sort of cooperation. In Spain there is a National Water Council and then specific councils for each river basin, where all water stakeholders participate.
- Based on projections regarding the development of demand for the different water uses, rules should be put in place to ensure the priority access of drinking water suppliers to water resources in times of water scarcity. Some countries already have a hierarchy of water uses (e.g. Denmark, Netherlands, Spain).
- The regulatory framework should provide for tariffs reflecting the availability of drinking water resources. Tariffs should promote the sustainable use of water. Spain, for example, introduced consumption blocks, where the more you consume the more you pay per cubic metre, to raise awareness about the availability of water.

Drinking water supply should also be secured through:

- official spatial planning and water resources planning and approval procedures,
- the provision of sufficient water rights to meet peak demands,
- consulting with utilities and other stakeholders, such as competent authorities with the aim of reducing consumer water demand, granting priority access to public water supply in the case of uncertain power supply,
- limiting agricultural irrigation needs by developing drought-resistant crops and mandatory crop rotation, as well as modernising irrigation and improving irrigating planning and techniques,
- optimising the safety of water supply, i.e. through the development of integrated supply systems,
- including water supply facilities in official flood protection programmes and schemes.

On the **waste water** side, the following conditions should be ensured:

~ The waste water and storm water-related effects of climate change need to be addressed at the urban level. Meeting the costs of adaptation measures for urban drainage is a major challenge (as is the cost of non-action), which may also encompass other challenges such as energy and transport. The waste water sector could be a driver for the transition to a climate resilient city by providing capacity building and developing holistic solutions, including green-blue infrastructures that integrate common adaptation needs to both floods and droughts in cooperation with municipalities and private land owners.

~ As to the use of reclaimed water, the ongoing regulatory action at EU level on agricultural irrigation is an important first step to provide the appropriate regulatory framework.

~ The implementation of Urban Drainage Master Plans, to holistically integrate strategies that prevent floods and prevent CSO's, are a key tool to adapt to climate change impacts.

~ The coordinated management of urban drainage systems and waste water treatment plants allows us to better cope with the uncertain scenarios that climate change may imply.

~ The revision of the Urban Waste Water Treatment Directive should consider the impacts of climate change on the waste water system, and do it in a coordinated way with the environmental objectives set in the Water Framework Directive, in order to protect water bodies from the impacts of discharges, especially in case of droughts and scarcity.

6.6 Providing adequate financing tools

The full and timely implementation of measures requires adequate financing which water utilities may not be in a position to provide. As mentioned in chapter 6.5, the topic of financing must therefore be included in the governance system regarding climate change adaptation, while maintaining full transparency.

~ It must be clearly determined who provides the financial means to implement adaptation measures at all levels.

~ For example, municipalities have to approve measures increasing their resilience against rain storms and drought, determine the responsible entity and decide who bears the cost. Local taxes and/or allocations from regional or national governments should finance those measures the municipality is responsible for and water tariffs and/or transfers should finance the measures the water company is responsible for. Private property owners must finance measures on their land.

~ When the measures can be seen as actions substituting the existing/planned service from the water sector, the utility can finance these. In this context the economic estimations have to be based on both cost-efficient-solutions and a common decision between the authority and the utility on choosing this measure. An alternative to the voluntary agreement/common decision is one from an independent regulator.[6]

- Municipalities are responsible for planning, roads and public areas. It is therefore natural that costs for taking measures on the surface in these areas shall be financed by taxes or transfers.
- The tariff system differs a lot across Europe concerning storm water treatment. In some countries, tariffs are calculated specifically for the individual house owner, depending on multiannual average quantities of rainwater, related to the permeability of the surface and the size of the surface. The tariffs are supposed to finance the water operators' measures to take care of normal precipitation, not heavy rain.
- On the **drinking water** side, financing may include investments to ensure the long-term water supply especially when new water resources need to be tapped into (sea water etc.).

6.7 Sharing best practice

Many countries, regions and municipalities are firmly engaged on the ways towards climate change resilience. Multiple measures are being implemented, but uncertainties as to their effectiveness may remain. At the same time, countries less exposed to droughts in the past, may learn from the long-standing experience of their counterparts in the Mediterranean basin.

With this in mind, the European Union and its member and partner countries should encourage and support the sharing of best practices. Learn from others also means reducing the risk of failure and the related financial losses.

[6] This is an existing system in Denmark, where more effective and cheaper above-ground solutions are substituting traditional planned services which typically are underground.