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Chapter 11

Cross-cutting Perspective Freshwater

Carina Furusho, Rodrigo Vidaurre, Isabelle La Jeunesse
and Maria-Helena Ramos

11.1 Introduction

One singularity of northwestern Europe (NWE) is that severe droughts are rare events in the region and water scarcity has hardly been experienced in its history. The DROP pilot sites are not exceptions to this context. Although the lack of a drought history in wet areas can explain why drought and water scarcity are not necessarily the focus of (if ever considered in) river basin management plans, it must be noted that freshwater availability for drinking water provision remains a priority stake in both quantitative and qualitative aspects. Providing a reliable and safe supply of drinking water may thus be a leading entryway to the development of drought risk awareness and drought adaptation measures in a river basin. When such essential resource is threatened and the competition for water among users increases, there is a good chance that reflections and changes will be triggered.

Water use conflicts and drinking water supply threats may arise due to increased water demand, but also due to decreased water availability. The later may occur because of natural climate variability, i.e., drier years than average, or as the result of the impact of climate change on local water resources. Climate change awareness is then an important asset to manage water availability. Where climate change awareness is low and adaptation measures are basically inexistent, social and political responses to drought adaptation may be slow and inefficient. However, even in those cases where climate change awareness is still low in general society,

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Fig. 11.1 The Drézet drinking water plant, in the Vilaine catchment. *Photo* Carina Furusho, 16/09/2013

water authorities and other stakeholders are conscious that water demand tends to intensify with population and economic growth, rendering water scarcity conceivable and even foreseeable.

Freshwater availability for drinking water supply is therefore an issue that can motivate the introduction of drought and water scarcity risks into the political and public agenda, even in “drought-scarce” regions. This chapter highlights the links between drought governance and the vulnerability of freshwater for drinking water supply, with a focus on drought adaptation. The main issues presented here are illustrated with how freshwater issues are managed in the DROP project cases with a particular focus on the two “freshwater reservoir” pilot sites: the Arzal dam in Brittany France (see Chap. 6) and the Eifel-Rur in Germany (see Chap. 4). Those two cases deal with reservoir management not only for drinking water supply (Fig. 11.1) but also for other uses, with various priority sets.

11.2 Drinking Water Scarcity Risks

11.2.1 *Relationship between Water Quality and Water Quantity for Freshwater Uses*

During drought episodes, water quality in lakes and reservoirs generally shows deterioration due to less dilution, particularly for nutrients and salinity (Mosley 2014). The increase in salinity observed in most lakes and reservoirs during droughts has been often attributed to reduced flushing/outflows and evapoconcentration,

rising concentrations of components due to evaporation (Mayer et al. 2010; Mosley et al. 2012; Burt et al. 2014).

Although the IPCC fourth assessment reports that an increase in average temperatures of several degrees as a result of climate change will lead to an increase in average global precipitation over the course of the twenty-first century, this amount does not necessarily relate to an increase in the amount of drinking water available. A decline in water quality can result from the increase in runoff and precipitation. While the water will carry higher levels of nutrients, it will also contain more pathogens and pollutants. These contaminants were originally stored in soils and in some groundwater reservoirs but the increase in precipitation will flush them out in the river (IPCC 2007).

Similarly, when drought conditions persist and groundwater reserves are depleted, the residual water that remains is often of inferior quality. This is a result of the leakage of saline or contaminated water from the land surface, the confining layers, or the adjacent water bodies that have highly concentrated quantities of contaminants. This occurs because decreased precipitation and runoff results in a concentration of pollution in the water, which leads to an increased load of microbes in waterways and drinking water reservoirs (IPCC 2007).

Water quantity and water quality are thus intrinsically related either in the case of single or multipurpose reservoirs. Their dynamics can be complex, with implications on reservoir operation and control. In the case of the freshwater reservoir of the Vilaine catchment in Brittany, France (Chap. 6), the operation of the locks of the Arzal dam, an estuarine dam in the Atlantic Ocean, is one of the main aspects that influence the quality of the water in the reservoir. The increase in salinity is aggravated by the salt intrusions from the estuary through the opening/closing of the boat lock of the Arzal Dam. The water quality upstream the Arzal Dam is essential to the Drezet-Férel water plant, which provides more than 15 million m³ of clean drinking water per year to the surrounding population. Salt intrusion deteriorates water quality and provokes the use of siphons that pump water out of the reservoir, back to the ocean. Freshwater is often lost, unavailable for drinking water supply. Integrated quality–quantity management is crucial, notably during summer, as this is the period with highest water consumption, increased number of lock openings for touristic boats, but also the low flow period of the Vilaine River, which is the main inflow of surface water to the reservoir.

In the case of the freshwater reservoir in Eifel-Rur managed by the WVER water board, Germany (Chap. 4), it is mainly the increase in water temperature during drought and low flow periods that can be a serious constraint for drinking water supply. Water must be less than 10 °C to comply with the strict requirements of the German Drinking Water Ordinance. Drinking water regulation limits can be exceeded for a period of 30 days, but only under certain critical conditions. Warmer temperatures not only increase the rate of evaporation of water from the surface of the reservoir into the atmosphere (loss of water quantity), but may also affect water quality, interacting with the amount of organic material in the water, the concentration of pollutants. When the water is warmer, its ability to hold oxygen decreases. The health of a water body is dependent upon its ability to effectively self-purify

through biodegradation, which is hindered when there is a reduced amount of dissolved oxygen. Consequently, when precipitation events occur, the contaminants are flushed into waterways and drinking reservoirs, leading to significant health implications.

Although freshwater is the main issue of the two pilot cases mentioned above, other DROP cases also face challenges concerning drinking water provision due to the risk of droughts and water scarcity. For instance, due to its hydrographical situation, water quality in Flanders is subjected to strong impacts on their water volumes and quality caused by upstream countries (see Chap. 7). When interviewed about drought and water scarcity, stakeholders insisted that a rigorous transnational agreement on water volumes and quality crossing the border is essential to avoid political tensions. Another example is the case study in the United Kingdom (see Chap. 5). In order to improve service and quality standards related to drinking water, water companies have been privatized since 1989, in order to increase investment in water and wastewater infrastructure (Water UK 2015). Finally, for both pilot cases in the Netherlands (see Chaps. 8 and 9), water quality has been mentioned as an issue that has been well regulated by successive programs, among which the most recent one is the Delta Decision Freshwater in 2015. Ensuring sufficient freshwater for all water uses, including the environmental (“nature”) perspective, is in principle a public task in the Netherlands.

11.2.2 The Diversity of Water Consumption Monitoring Situations

Besides intensifying the challenge of maintaining freshwater quality and quantity for drinking water provision, drought and water scarcity planning also requires better monitoring systems of withdraws to manage water flow and freshwater availability. Monitoring water use, particularly for groundwater, is an issue that is treated differently in each site studied within the DROP project. For instance, in the Vilaine pilot, we observe that only withdrawals related to drinking water are systematically monitored. The knowledge on the water extractions for other uses (industrial, irrigation, and livestock) is much more fragmented because it is not relayed to the water administration, even though it is a legal obligation.

In Groot Salland, in the Netherlands, the water boards ask each farmer once a year to inform about their water extraction levels, although they have concluded that this information is not accurate enough to manage water flows and groundwater levels. Farmers rarely admit having exceeded withdrawal limits. To face current monitoring challenges there are plans to introduce flow meters to monitor water withdrawals at the field. Stakeholders of different water sectors in Flanders also believe that providing drought-risk-related data and good risk communication are essential to incorporate drought risks into their risk management practices in their business. The situation is quite different in Eifel-Rur, where stakeholders indicated

that systematic water metering is still not under discussion. The insufficient data collection for flow management could be related to the lack of updated legal requirements.

11.3 Different Priority Settings and Potential Tensions

The fact that floods and droughts are semantically opposites does not mean that any flood control measure is necessarily hindering drought risk management. Conversely, they should not be dealt with separately. People have been fighting against flood risk in all these regions for a longtime, and a dynamic synergy has built among stakeholders. It was clear that stakeholders got used to work together and discuss water-related problems. In that sense, flood risk governance has contributed to bridging connections between stakeholders that can potentially enhance drought governance. However, in terms of synergies, it will also become increasingly important to ensure that the policy measures, and concrete strategies and instruments designed to deal with flooding for each region, are not counteracting any policy developments made for drought and water scarcity.

Drinking water production and flood protection are the main objectives guiding the dam management of both water boards in Vilaine and Eifel-Rur. However, there is a subtle difference that can be noticed when discussing with stakeholders in the way these two priorities are handled by the water boards, reflecting some divergence in perceptions, flexibility, and regulation context between the two cases.

The management rules of the Arzal dam, appended to the Water Management Plan (Schéma d'Aménagement et de gestion des eaux SAGE, see Chap. 6), reflect the hierarchy of objectives to be achieved. Drinking water provision is the first priority and it is widely accepted by all stakeholders interviewed in the Vilaine governance assessment meetings.

In Eifel-Rur the obligation of the water board to provide a well-established level of protection against floods seems to overcome the guarantee of continuous drinking water production. In this context, adapting the dam management rules to prevent water scarcity, even when there is a clear deficit of precipitations (reservoir recharge), is quite troublesome. For this reason, achieving all the high water quality standards demanded by German regulation can be very complicated in drought situations. The strategy for flood prevention in Eifel-Rur implies that the water level in the reservoir must be kept sufficiently low during the winter until the spring to ensure enough storage capacity in case of exceptional flood events which may be associated with intense rainfall or snow melt. However, if there is not enough precipitation or snow melt during the spring period, when water is collected, there is not enough water to meet all the quality conditions for drinking water providers (e.g., water temperature below 10 °C and oxygen above 4 mg/l). It is a lengthy process to change the flood protection rule to adapt the reservoir level for drinking water purposes in cases when precipitations arrive earlier than expected. The water board first needs to prove, based on data analysis, that the proposed changes would

not compromise safety-concerning flood risks. In this sense, the requirement for evidence (based on simulations using historical data) can slow down the implementation of adaptation measures: the legal aspects bring with them a reluctance to take responsibility to adjust management rules without clear science-based evidence.

Water use ranking in case of drought and water scarcity is a subject that has not been highlighted by stakeholders in the DROP project interviews in Somerset, but drinking water and environment tend to get priority all over England with different expressions in regions according to the Water Act 2003. The priorities established by the Dutch national “*verdringingsreeks*” (displacement chain) in case of serious freshwater shortage are not the same as in France and Germany. Preventing irreparable damage to the water system, the soil (e.g., peat layers) or nature is the first priority of the chain. Drinking water and energy production come as second in line, followed by high-value agricultural and industrial production processes and last by the interests of shipping, general agriculture, nature with resilience, industry, recreation, and fishery.

Surprisingly, there is no “hierarchy” or prioritization of different water uses/demand if a situation of water scarcity occurs in Flanders. The VMM water board, which is developing physical drought indicators provided by modeling assessment tools for the monitoring and reporting of the drought situation, is now getting this issue on the agenda. The fact that drinking water companies set lower prices for large-volume consumers, as some industries, does not contribute to regulating demand and is not coherent with the general aims of the water board, particularly in the perspective of preserving environmental flow.

In Vechtstromen, the second DROP case study in the Netherlands (see Chap. 9), increasing extractions for irrigation and drinking water threatens the groundwater-sensitive areas. As a result, the farmer organizations and drinking water companies are opposed to nature conservation organizations. Province and Vitens (the local drinking water producer) are looking for ways to protect drinking water resources by combining nature and drinking water protection through the involvement of water boards and farmers. Vitens provides financial compensation to the farmers and for nature areas that are affected by its water abstractions.

In Eifel-Rur, the obligation of the water board to provide a well-established level of protection against floods and drinking water supply, with all the responsibilities associated, have resulted in an elaborate and sophisticated set of rules to manage the interaction of reservoirs and water bodies. These legal obligations restrict the possibility of officially incorporating additional risks (e.g., droughts) into the set of priorities which govern the system. Even small changes have to be extremely well founded and well argued, based on technical evidence and modeling of historic data. The overall framework is therefore destined to be rather reactive than proactive, and these reactions tend to take time. The management of secondary objectives or other unconsidered aspects can only be improved if it can be shown that primary objectives are not affected. This means that the adaptation of dam management rules to drought and water scarcity is a lengthy procedure.

11.4 Multilevel and Multiscale Issues and Measures

A comparative analysis of three drinking water provision issues, in the Vilaine, in Eifel-Rur, and in Flanders, can be particularly illuminating, as they present similar problems in very contrasting contexts, different levels, and scales involved as well as a diversity of other factors influencing them. In the case of the **Vilaine**, problems of water quantity related to the Arzal dam reservoir translate into a problem of water quality. As explained in further detail previously in this chapter, in dry periods the low inflow from the Vilaine river and the intrusion of salt water through the lock for sailing boats are increasingly causing water quality bottlenecks for the drinking water plant. The position of the reservoir at the river mouth is downstream the big catchment area affecting the reservoir (of slightly over **10,000 km²**), which in turn implies **a large scale and a huge number of administrative levels** to be potentially involved in the different possible solutions. This position of the reservoir also means that it is impacted by the water management decisions of many different actors and sectors. A series of sectors (including the traditionally strong agricultural sector) rely on water management, both in terms of water availability and in terms of water drainage, and for decisions affecting the region's water management the different needs have to be aligned between the parties.

Whereas this dependency of drinking water provision on the outcomes of water management measures (such as those derived from the implementation of the WFD) would seem a problematic dependency, in practice the Vilaine catchment water board (IAV) is responsible for both drinking water provision for water companies and for implementing the Water Framework Directive. This means that it is in a privileged position to keep track of issues affecting water quality and react accordingly to possible problems. IAV has recourse to an array of possible solutions to address their water quality issues. For instance, they have the possibility of implementing measures throughout the catchment in order to avoid excessive water level drop in summer months by adding small dams along the stream and tributaries. However, these options seem less attractive than improving the lock system to decrease saline water intrusion, which is the solution that the IAV is currently evaluating using a prototype (within the DROP project framework). The solution addresses an existing inefficiency and does so at one point which is under the management control of the water board. Decentralized options may require the cooperation of other stakeholders and continuous efforts over time and therefore seem more complex to implement efficiently.

In the case of the **Eifel-Rur** region, dry years also create water quality problems in one reservoir, but these problems are of another kind, as they are related to issues of eutrophication. Dry years thus mean that the quality and temperature of the water provided by this particular reservoir can be compromised; creating issues for the drinking water company supplied by the water board. The issue is **very limited in scale, as the affected reservoir is upstream within the watershed**. The reservoir's catchment area is mountainous, mainly forested (i.e., not much agriculture), has hardly any population, and with a size in the order of **a few hundred km²**. This

implies on the one hand that there are not many actors to be dealt with, whose interests would have to be aligned in possible measures. On the other that there are few control structures affecting springtime water availability which could be managed to improve water availability. Indeed, one possible solution is to adjust management plans so as to allow for more “winter water” to be kept in the reservoir under dry hydrological conditions; the increase in water quantity would help to avoid the decrease in water quality and its temperature rise.

The approach chosen by WVER—to adjust operating rules to be better prepared for dry years—is thus an issue requiring interaction with few stakeholders. The problem is fundamentally one of legal responsibility (how to increase “winter water” in the reservoir without affecting the water board’s other legal requirements such as flood protection; this issue could potentially be related to expensive litigation), so discussions are directly with the relevant authority. Since the required agreement involves only authorities and the water board, the scale of the reservoirs management in Eifel-Rur is quite limited compared to the Arzal Dam management.

Flanders relies on a mix of groundwater and surface water for its drinking water provision, and summer low flows in the large transboundary rivers that cross the country are accompanied with water quality issues. In recognition of this problem (which is not new), water companies have infrastructure which allows the retention of higher quality “spring” river water for use over the summer months. However, longer dry periods mean that this buffering capacity no longer seems sufficient, and both authorities and drinking water providers admit the necessity of increasing the volumes retained—which means building additional retention infrastructure. The water quality of the rivers that flow through Flanders is beyond the control of the region or even of Belgium, as these are large international river basins (Meuse: **34,548 km²**; Scheldt: **21,863 km²**) covering a huge geographical scale and levels going up all the way to the international. As an overall conclusion, the drought-related issues affecting drinking water in the northwestern European pilots were not directly a problem of water availability, but of limited water flow generating different water quality consequences. Longer periods of low flow (Vilaine, Flanders) or changed precipitation patterns (Eifel-Rur) affect water quality negatively, to the point that drinking water companies see the need for (sometimes expensive) action. In all three areas, and in spite of the largely different scales, the planned responses were related to infrastructure: improving infrastructure by eliminating existing inefficiencies (Vilaine), increasing the capacity of infrastructure (more reservoir capacity in Flanders), or adjusting operational rules of infrastructure.

11.4.1 Coordination Above Local Level for Increased Resilience

When it comes to drinking water supply, the case study areas exemplify a broader trend of increasing spatial water connectivity between neighboring water service

Netherlands, water supply companies are publicly owned private companies, with often dozens of municipalities and provinces as owners. They are submitted to the national “drinking water regulation” determining the maximum return for invested capital, therefore regulating the price of tap water. The companies have no pressure to maximize prices and instead have a sort of corporate pride in delivering good quality water for a modest price.

The UK has privatized drinking water companies. They are responsible for the abstraction of water from rivers and streams and aquifers for drinking water supply, but they also have a range of roles and responsibilities in environment conservation and drought and climate change adaptation planning. Their company borders do not necessarily map onto watersheds. Even in the context of this particular setting, the full range of administrative levels and scales are involved in drought management and water scarcity for drinking water in the Somerset region. However, this setting also creates some cross-boundary issues that span drinking water supply, environmental flow, and agricultural water use. The water companies have a drought plan that covers drinking water supply (in balance with other environmental factors like flow), but the Environmental Agency has another drought plan that includes both water supply and irrigation issues covering a region rather than just a water company.

11.4.2 Larger Scales for Long-Term Strategies

Moving up to the regional-level implication in drinking water supply, in Eifel-Rur, the district level focuses in long-term development of regional water management. In Vilaine, the regional coherence in terms of water planning is ensured by the SAGE (Schéma d’Aménagement et de Gestion de l’Eau). The sustainability and the quality of the drinking water resource is the major issue that framed the SAGE Vilaine and the debate between all actors involved. Similarly in Flanders, the regions are the ones responsible for water policy, including drinking water quality.

The economic aspects of drinking water provision (i.e., the establishment of maximum prices and the approval of price increases) are often managed at the national level. That is the case with the Federal Government in Belgium and also in the UK, where the OFWAT (the Water Services Regulation Authority) is the financial and economic regulator of the water and sewerage sectors. They have a duty to set the price, investment, and services standards. In France, the legislation designates that “drinking water pays for drinking water”, imposing an independent budget of drinking water supply and other water management sectors. The price of water is also fixed and indexed to the cost of its management.

Drinking water supply is also dealt with in transnational economical arrangements, as the Eifel-Rur drinking water producer sells water to Belgium and the Netherlands. In Flanders, a key instrument that seems to be missing is the transnational agreement of flows over borders, particularly with France. Drinking water companies complain that the water quality is hard to maintain when flows are

reduced, especially during dry summers. The lack of such agreements also delays authorization for the establishment of new drinking water production facilities. Political will to develop a legal framework seems to be lacking, but there is also a problem of leverage of the French government.

Drinking water standards, wastewater discharges, and other issues are also governed by the Water Framework Directive across EU countries. It was noticed that EU environmental policies seem to play an important role to introduce a more holistic and synergistic approach to drinking water supply and the management of the reservoirs. At the same time some stakeholders interviewed in Eifel-Rur expressed criticism of EU regulations, which are seen as “imposed from Brussels”. The existence of such a “distant” authority has shown to be beneficial when unpopular measures must be pushed by the water boards, as they can argue that they have no choice but to comply with EU directives.

11.5 Awareness and the Public and Political Agenda

The interview campaigns held within the DROP project highlighted that the broad public is in general unaware of the risks and challenges water providers are facing due to drought. Users are accustomed to a high quality of service 24 h a day, 7 days a week; service interruption is seen as someone not having done his homework, rather than a possibility that can arise as a result of different natural risks to service provision. In addition, stakeholders highlighted that the broad public is typically unaware of the sources of their drinking water. In the Eifel-Rur region, for instance, the overall public perception is that the reservoirs provide other more visible services than drinking water, such as flood protection or opportunities for sailing and tourism attraction. This lack of awareness is a drawback when trying to communicate drought risks to the broader public (La Jeunesse et al. 2015).

Communication on droughts faces additional challenges in these flood-prone regions. These highly visible impacting events convey to the broader public the idea that a certain region’s problems are related to dealing with too much water, and not too little of it, as far as reservoirs are managed for protection against floods and also sustain stream flows during low-flows periods. Conveying the concept that flood risk does not imply an absence of drought risk is a communicational challenge.

Awareness of the topic among stakeholder groups seems not much higher than that of the broader public. Stakeholders, in general, do not consider drought and water scarcity issue as urgent from their perspective, and there is a lot of interest in keeping up business as usual or even in expanding water uses. The exceptions to this rule are the drinking water providers themselves—some proof is given by the fact that the water boards IAV and WVER are part of the DROP project, and in Flanders drinking water providers also counted this issue as on their agenda. Beyond drinking water providers, some environmental authorities considered were showing interest in the issue, fundamentally due to the environmental problems that could derive of the low flows. Somewhat surprisingly, environmental NGOs in the

Vilaine region, Eifel-Rur, and Flanders saw the topic as an issue but not significant enough to consider it one of their priorities.

It is probably for this reason that drought is not very present on the political agendas of the analyzed regions: since stakeholders groups as yet mostly are disengaged with the topic, there is no pressure by the electorate or by interest groups on the political or administrative levels to support this topic. In addition, issues of water use and expansion of water use often involve strong economic interests. Stakeholders express that it can be very hard to argue against economic uses of water. In the Eifel-Rur region the paper industry and farmers have significant political influence, also related to the amount of jobs they create in the region. A similar situation was observed for farmers in Flanders and Somerset (UK). With the current political agenda very much pro-growth, it would seem that there is not much potential for the uptake of an issue which stakeholders reject due to the possible impacts on business opportunities.

11.6 Conclusion: Diagnosis and Scenarios

Currently, drought management practices in NWE are largely based on crisis management. The effectiveness of these practices is questionable because they are reactive, dealing only with the impacts of drought rather than tackling the causes of the vulnerabilities. This does not promote the anticipation of adaptation strategy development while measures can require time to be operational. Proactive management has generally been implemented in case studies following drastic droughts (Dennis 2013; Krysanova et al. 2008). The consequences of disasters can create sufficient public and institutional willpower to lead authorities and stakeholders to design and implement proactive approaches to mitigate impacts of future drought episodes.

In the case of the Northwest European region, there is still a visible inertia to start moving toward the development of adaptation measures to improve drinking water supply systems' robustness. This inertia seems to be mostly due to the lack of severe drought and water scarcity episodes in the collective memory that motivate other regions to mobilize stakeholders of all levels to tackle these problems when they are really experienced.

Even in these cases where climate change awareness is still quite low and where drought and water scarcity have hardly been experienced, the essentiality of drinking water supply and freshwater availability may be the leading entryway to the development of drought risk awareness and drought adaptation measures. Most people are aware that fresh water is a limited resource and that water demand is indeed increasing with population growth and economic development. This perception helps them realize that the threat of water scarcity is possible and foreseeable, even if they have not experienced it in the past. That is why the issue of drinking water provision is a key factor to be highlighted to push forward adaptation measures to prevent drought and water scarcity.

One important step toward this objective is the implementation of better monitoring systems of water withdraws to manage water flow and freshwater availability, as it has been highlighted by the analysis of the DROP pilot sites. In fact, besides monitoring water withdraw, all the data that can contribute to a better understanding of the water cycle is worth being collected to provide the basis for science and best practices in hydrology, water supply systems, geomorphology, drainage network, and land use management. An enhanced knowledge of drought impacts and of hydrologic patterns contributes to achieving greater effectiveness of adaptation measures and target management efforts.

The well-developed flood risk governance in pilot cases seems to have contributed to creating synergies among local stakeholders that can participate in building integrated water-related risks (including droughts) governance together. Future actions that could enhance drought resilience include the following strategies (selected from the study of Dennis 2013):

- New sources of water from outside the region are pursued to meet demands (drinking water supply systems interconnectivity).
- Residents collect gray water for outdoor use.
- Cities utilize policy instruments (like financial incentives) to reduce water use.
- Water quality regulations are precautionary and protect against new and potentially harmful pollutants.
- Natural areas along streams are restored and protected for fish and wildlife.
- Safe yield is a central guiding principal in water management.

The evolution of regulations and policy instruments depends greatly on changes of the political agenda in the region, the main topic was discussed in the previous Sect. 11.5 of this chapter. The first point actually concerns measures that have already been identified and even started to be implemented by water managers in NWE. However, the actions that require a paradigm shift to a most systemic strategy including water demand control remain out of the agenda and could greatly improve the resilience of the region to drought and water scarcity rising risk.

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References

- Burt TP, Worrall F, Howden NJK, Anderson MG (2014) Shifts in discharge-concentration relationships as a small catchment recovers from severe drought. *Hydrol Process* 29(4):498–507. doi:[10.1002/hyp.10169](https://doi.org/10.1002/hyp.10169) Accessed 16 Dec 2015
- Dennis L (2013) Proactive flood and drought management. A selection of applied strategies and lessons learned from around the United States. http://www.awra.org/webinars/AWRA_report_proactive_flood_drought_final.pdf. Accessed 20 Oct 2015
- IPCC (2007) Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change core writing team. In: Pachauri RK, Reisinger A (eds) IPCC. Switzerland, Geneva, p 104
- Krysanova V, Buiteveld H, Haase D, Hattermann FF, van Niekerk K, Roest K, Martinez-Santos P, Schlüter M (2008) Practices and lessons learned in coping with climatic hazards at the river-basinscale. *Floods and drought. Ecol Soc* 13(2):32. <http://www.ecologyandsociety.org/vol13/iss2/art32/>. Accessed 21 Oct 2015
- La Jeunesse I, Cirelli C, Larrue C, Aubin D, Sellami H, Afifi S, Bellin A, Benabdallah S, Bird DN, Deidda R, Dettori M, Engin G, Herrmann F, Ludwig R, Mabrouk B, Majone B, Paniconi C, Soddu A (2015) Is climate change a threat for water uses in the Mediterranean region? Results *Surv Local Scale Sci Total Environ*. doi:[10.1016/j.scitotenv.2015.04.062](https://doi.org/10.1016/j.scitotenv.2015.04.062)
- Mayer B, Shanley JB, Bailey SW, Mitchell MJ (2010) Identifying sources of stream water sulfate after a summer drought in the sleepers river watershed (Vermont, USA) using hydrological, chemical, and isotopic techniques. *Appl Geochem* 25(5):747–754
- Mosley LM (2014) Drought impacts on the water quality of freshwater systems; review and integration. *Earth-Science Reviews*, vol 140. Jan 2015, pp 203–214. ISSN 0012-8252 <http://dx.doi.org/10.1016/j.earscirev.2014.11.010>
- Mosley LM, Zammit B, Leyden E, Heneker TM, Hipsey MR, Skinner D, Aldridge KT (2012) The impact of extreme low flows on the water quality of the lower Murray River and Lakes (South Australia). *Water Resour Manage* 26:3923–3946
- Water UK (2015) Price reviews. <http://www.water.org.uk/price-reviews>. Accessed 12 Dec 2015