PART II

*Chapter 3*

# Overview of case studies

*This chapter provides an introduction to nine case studies of groundwater allocation in Denmark; Tucson, Arizona; Kumamoto, Japan; Mexico; the Upper Guadiana Basin, Spain; Texas; France; India and North China). It briefly summarises the challenges related to groundwater allocation examined and the elements of the "Health Check" discussed in each case study.*

Groundwater allocation poses numerous challenges related to managing both the quantity and quality of the resource, conditioned by the magnitude and type of groundwater use, interactions with surface water bodies and impact on groundwater-dependent ecosystems. The cases presented in the chapter present a range of policy responses put in place to address these challenges in various contexts. The selection of cases was driven by the aim to examine a broad range of groundwater allocation issues, in particular those that were relatively less well-developed in previous work. These include the reallocation of groundwater for environmental purposes and among different types of users; the use of economic instruments, such as abstraction charges and groundwater markets; interactions between quality and quantity aspects of groundwater management; long-term groundwater abstraction limits and the use of proportional pumping restrictions; artificial groundwater recharge; and innovative approaches to the collective management of groundwater allocation.

Table 3.1 provides an overview of the key issues examined in each of the case studies using elements in the *Health Check for Water Resources Allocation* as a framework. The *Health Check* is presented in detail in Chapter 2, along with the policy guidance reflecting good

Table 3.1. **Case studies illustrating the OECD Water Resources Allocation Health Check in practice**

| | Denmark | Tucson, Arizona, US | Kumamoto, Japan | Mexico | Upper Guadiana Basin, Spain | Texas, US | France | Gujarat, India | North China |
|---|---|---|---|---|---|---|---|---|---|
| **Check 1.** Accountability mechanisms in place for the management of allocation | | ✓ | | | | ✓ | ✓ | | |
| **Check 2.** Legal status for all water resources (surface and ground water and alternative sources of supply) | | | | | ✓ | ✓ | | | |
| **Check 3.** Understanding the availability of groundwater resources and possible depletion | ✓ | ✓ | ✓ | ✓ | | | | | |
| **Check 4.** Abstraction limit ("cap") reflecting *in situ* requirements and sustainable use | ✓ | | | ✓ | | ✓ | ✓ | | |
| **Check 5.** Approach to enable efficient and fair management of the risk of shortage that ensures water for essential uses | | | | ✓ | | | | | |
| **Check 6.** Arrangements in place for dealing with exceptional circumstances (such as drought or severe pollution events) | | | | | | | ✓ | | |
| **Check 7.** Process for dealing with new entrants and for increasing or varying existing entitlements | | | | | ✓ | | ✓ | | |
| **Check 8.** Mechanisms for monitoring and enforcement, with clear and legally robust sanctions | ✓ | | | | | ✓ | | | |
| **Check 9.** Water infrastructures in place for the allocation regime to function effectively | | ✓ | | | | | | | |
| **Check 10.** Policy coherence across sectors that affect allocation | ✓ | | ✓ | ✓ | | ✓ | | ✓ | |
| **Check 11.** Clear legal definition of water entitlements | ✓ | | | | ✓ | ✓ | | | |
| **Check 12.** Abstraction charges | ✓ | | | | | | | | |
| **Check 13.** Obligations related to return flows and discharges | | | | | | | | | |
| **Check 14.** Allowing water users to reallocate water among themselves | | | | | | | ✓ | ✓ | ✓ |

practice. The case studies reflect the diversity of contexts and policy responses, demonstrating the importance of tailoring policies to specific conditions. While many of the cases attest to the challenges of groundwater depletion and related negative impacts that remain, the cases nevertheless illustrate the combination of policies that, taken together form an allocation regime, and can, when properly enforced, provide numerous levers to influence the behaviour of groundwater users and ensure the sustainable management of this valuable natural asset.

The case of Denmark provides an example of a comprehensive allocation regime, combining time-bound entitlements, a cap on total abstraction which accounts for environmental needs, economic instruments (volumetric water and wastewater tariffs, taxes, as well as a groundwater abstraction charge) and a well-developed monitoring network. The range of measures in place to protect groundwater quality is of particular importance, as groundwater provides nearly all drinking water in Denmark.

As a rapidly growing desert city that has been heavily reliant on groundwater, Tucson, Arizona in the U.S. provides an example of how developing a diversified water resources portfolio along with water banking and demand management has helped to eliminate groundwater mining as of 2015. Tucson's storage and recovery programme allowed for the water utility to overcome early challenges in integrating new surface water supplies into the system due to quality issues. The case also highlights the importance of flexibility in groundwater allocation and of concerted stakeholder engagement.

The case of Kumamoto, Japan provides an illustration of how a payment for ecosystem services (PES) scheme developed between industrial users and farmers to provide financial incentives for groundwater recharge. The scheme managed to raise groundwater recharge substantially, helping to ensure security of supply for industrial and other groundwater users. Based on this success, the scheme has steadily expanded.

The case studies of both Mexico and Spain examine how concerns about environmental degradation due to groundwater depletion have spurred policy efforts to reallocate water for environmental purposes. In Mexico, groundwater depletion due to uncontrolled pumping has resulted in substantial land subsidence, increased costs of urban and rural water supply and caused the deterioration of groundwater quality. Attempts to exert greater control over pumping have been stymied by weak enforcement. The adoption of the 2012 standard for determining environmental flows was a positive step towards securing water for the environment, however, ambiguity and lack of coherence in national legislation pose challenges to the standard's successful application. In Spain, irrigated agriculture in the Upper Guadiana Basin spurred remarkable socio-economic development, although sharply increased groundwater abstraction resulting in a major decline in the water table. This severe drop negatively impacted several wetlands in the basin, including the famed Tablas de Daimiel National Park, a Ramsar site, which provided valuable ecosystem services (fisheries, crabbing, orchards) to the surrounding population. Over decades, Spanish authorities have put into place policies and legal changes to shift groundwater from private property to a resource managed under the public domain and established pumping quotas. While monitoring and enforcement has been a challenge, these efforts have helped to move from a severely over-abstracted situation towards greater control over abstraction, thereby contributing to the gradual recovery of the aquifer. An ambitious plan to reallocate water to higher value uses and towards environmental purposes has not been fully implemented due to very high costs and budget constraints. However, groundwater levels have recovered the basin, in large part due to high precipitation in recent years, contributing to wetland restoration.

The cases covering examples from Texas, France, India and China highlight how issues related to groundwater allocation for irrigation have been addressed in diverse settings. In some areas of Texas, the Ogallala Aquifer has been subject to depletion for over a half century, resulting in subsidence, brackish intrusion as well as posing a risk to irrigated agriculture and hence, the local economy. Groundwater conservation districts have proved to have a positive impact on the level of groundwater depletion, yet have given rise to conflicts with private property claims, making authorities more reluctant to limit pumping permits in cases where this may result in costly litigation and compensation claims. In the Texas Panhandle, the "50/50"conservation scheme provides a good example of concerted and rigorous long term planning to explicitly account for intertemporal allocation and provide an incentive for farmers to adopt water conservation practices.

In France, the government has instituted a novel institution, the *organismes uniques de gestion collective* (OUGCs), or single collective management bodies, to allow water users to take on the task of allocating a fixed abstraction limit among themselves. Yet, implementation has faced numerous challenges. The OUGCs have sparked strong controversy due to the conflictual relations between those exercising the tasks of the OUGCs and those that are meant to benefit from them (irrigators), as well as decision-making procedures which seem to limit the influence of some stakeholders. Furthermore, farmers have notably reacted to the fact that their individual, permanent water entitlements have been replaced by a collective quota. Also, a lack of clarity regarding key aspects in the legislation, including with regards to sanctioning and the judicial relation between the OUGCs and the farmers, has lead to further lack of support of the collective management model.

In India, where electricity subsidies provide a perverse incentive to pump groundwater, a scheme to ration electricity for the agricultural sector has reduced groundwater use and the cost of electricity subsidies. In North China, severe groundwater depletion presents a threat to the region's food production and economic development. Informal groundwater

### Box 3.1. **"Over-exploited": A contested term**

Several of the case studies refer to situations where groundwater resources have been considered "over-exploited". It is important to note that this is a contested term and there is no generally shared interpretation among groundwater specialists. It is employed divergently in different settings, depending on what is considered a normal or acceptable exploitation path.

From an economic perspective, the definition of "over-exploitation" should go beyond simply considering abstraction versus recharge. For example, mining groundwater in non-renewable aquifers to generate capital and invest in the future can be preferable to preserving the stock as such. To some extent, over drafting aquifers may lead to tremendous gains for farmers and communities by later increasing their capacity to adapt to future water constraints (OECD, 2015).

Thus, the definition of "over-exploitation" should be interpreted as a state where the economic, social and environmental costs from a certain level of abstraction exceed the benefits (Garrido and Llamas, 2007). This would imply considering a system in a dynamic cost-benefit analysis, which has merit but also faces challenges. In practice, water management bodies define quantitative reference states to which they compare groundwater levels. Some countries even define multiple water table threshold levels for intervention.

*Source:* OECD, 2015; Margat and van der Gun, 2013; Garrido and Llamas, 2007.

markets emerged as a response to the privatisation of wells, allowing for increased groundwater access for farmers that lacked the means to install their own wells. The markets are influenced by level of groundwater scarcity, with increased scarcity leading to expanded groundwater market activity. Because electricity tariffs in China are set based on metered consumption, the depth from which groundwater is pumped determines the costs of operating a tube well. When pumping costs are higher, water sellers as well as buyers tend to optimise their groundwater consumption, at least in terms of their private use.

### *References*

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