Groundwater Governance in Australia, the European Union and the Western USA

6

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Abstract

Groundwater governance can be defined as the system of formal and informal rules, rule-making systems and actor networks at all levels of society that are set up to steer societies towards the control, protection and socially acceptable utilization of groundwater resources and aquifer systems. Groundwater resources are very diverse and groundwater governance is complicated by the common pool nature of most groundwater resources, information gaps, and the diversity of stakeholders and their interests. There are few comparative studies of groundwater governance. This chapter contributes to that literature by means of a high level comparison of groundwater governance in Australia, the European Union and the Western USA. The comparison is structured using the five categories of governance issues defined in the Earth System Governance Project; architecture, access and allocation, accountability, adaptiveness, and agency – defined in this case as management organisation. The EU WFD has gone furthest towards an integrated framework to manage groundwater quantity and quality objectives, but there are many implementation challenges. Australia's system of annually adjustable water entitlements and related water markets provides security, efficiency and flexibility but it is not yet clear how successfully environmental water allocations can be integrated within this framework. The system of prior appropriation in the Western US provides clearly defined priorities for water allocation, but lacks flexibility during extreme droughts. Fully integrated groundwater management, as intended by the WFD, is a very ambitious goal. The advantages of a strong central direction and coordination together with decentralised local management could be obtained through

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a decentralised system of collaborative planning and management at sub-basin scales nested within an overarching groundwater planning framework at the jurisdictional or basin scale. This system could take various forms in different countries depending on social preferences and institutional settings and capacity.

6.1 Introduction

Groundwater makes up 30 % of the world's freshwater and 99 % of the world's liquid freshwater. Groundwater supplies over 40 % of global irrigation water and 50 % of municipal water withdrawals. Two billion people depend on groundwater for drinking water. The consumption of groundwater is growing rapidly driven by increases in global population and agriculture and overextraction, and pollution of groundwater is increasing in many parts of the world. This is reducing groundwater reserves and harming rivers and lakes that are connected to groundwater (see Chap. 2 for more detail on the scale of the groundwater problem internationally). As groundwater is depleted supply costs increase leading to reduced access for the poor (Wijnen et al. 2012). Therefore good governance, protecting groundwater resources is crucial, for environmental, economic and social reasons.

Several features of groundwater and its use present challenges for its governance. Firstly, groundwater resources are not visible or well understood. The impacts of groundwater use and pollution are often hidden, and only become apparent over tens or even hundreds of years (Moench 2004, 2007; Wijnen et al. 2012). Secondly, groundwater governance has to allow and account for the large diversity of groundwater resources, users and use impacts. Groundwater is also subject to a diverse range of point source and diffuse pollution. Thirdly, groundwater is often subject to unsustainable levels of exploitation and depletion, because it is a common pool resource – individual users cannot exclude others (Ostrom 1990; Ostrom et al. 1994). Fourthly, even when individual groundwater users collaborate, they cannot be expected to manage remote impacts of groundwater pumping on other resources and the environment. Because of these features groundwater governance is a complex process that requires coordination across multiple spatial and time scales, sectors and administrative levels. Partnerships between governing authorities and water users are needed to address these problems (Schlager 2007; Blomquist and Schlager 2008).

The definition of groundwater governance in this chapter is adapted from the definitions in the Earth System Governance Project (Biermann et al. 2009) and the global diagnostic on groundwater governance (GEF et al. 2015). Groundwater governance is defined as the system of formal and informal rules, rule-making systems and actor networks at all levels of society that are set up to steer societies towards the control, protection and socially acceptable utilization of groundwater resources and aquifer systems.

There are few comparative studies of groundwater governance. This chapter contributes to that literature by means of a high level comparison of groundwater governance in Australia, the European Union and the Western USA. The comparison is structured using the five categories of governance issues defined in the Earth System Governance Project; architecture, access and allocation, accountability, adaptiveness and agency – defined in this case as management organisation.

The remainder of this chapter proceeds as follows. The next section introduces the importance and special features of groundwater. These features present a number of challenges for groundwater management. The following section discusses the challenges for groundwater governance in terms of the five issues defined in the Earth System Governance Project. The main part of the chapter includes a comparison of groundwater governance in Australia, the EU, and the western United States. This is followed by a summary assessment of the strengths and weaknesses of groundwater governance in the three regions and some governance difficulties and dilemmas.

6.2 Framework for the Assessment of Groundwater Governance

Groundwater governance involves collective action to ensure socially-sustainable utilisation and effective protection of groundwater resources for the benefit of people and groundwater dependent ecosystems (Foster et al. 2009). Groundwater governance as defined in this project refers to forms of steering societies that go beyond government policy-making and include a wide variety of decision-making structures and processes at all levels of society. These involve a wide variety of non-state actors representing industries, scientists, environmental interests and other parties interested in groundwater (Foster and Garduno 2013). In the remainder of this chapter groundwater governance is analysed using a framework based on the five issues defined in the Earth Systems Governance Project (Biermann et al. 2009).

The Earth Systems governance framework enables a large number of governance issues to be grouped into five major classes: architecture, access and use, accountability adaptation and agency and some links between the five issue classes are also established within the framework. Further details of this classification applied to groundwater are given in Table 6.1 and in the remainder of this section.

Table 6.1 Classification of earth system governance issues

Architecture	Central principles, policies and institutions that guide sustainable groundwater use and protect groundwater quality, and interactions between them
Access and use	Institutions and procedures that determine who has access to groundwater, for what purposes and how groundwater is allocated
Accountability	Institutions and procedures that provide accountability for groundwater protection and use
Adaptation	How groundwater users, governments and third parties respond and adapt to changes and uncertainty in groundwater availability, use and governance
Agency	Private and public sector responsibilities for groundwater management

The classification aligns with major themes of governance research and the framework has been subject to extensive peer review and has now been in use for several years.

6.2.1 Architecture

Groundwater extraction always creates an impact on other resources or the environment somewhere in a hydrological system. Before extracting groundwater a decision is required about the sustainable level of impact that can be accommodated by the system. A sustainable yield can be determined by a combination of two elements. Firstly, stakeholders negotiate a "consensus" or "acceptable" yield that enables them to set management goals. The acceptable yield may be defined in terms of specified resource condition targets. Secondly, scientists and engineers calculate the "operational" yield – the amount of groundwater available through different methods able to meet management goals (Richardson et al. 2011; Pierce et al. 2011). Decisions about acceptable groundwater yield and resource condition targets depend on political judgements about the weights that should be given to consumptive and environmental water consumption now and into the future.

The difficulty of establishing quality standards for groundwater increases with the variability of water quality and use over space and time. Groundwater quality regulation requires definition of well-defined groundwater and environmental quality standards, indicators/measures that enable the achievement of those standards to be assessed, criteria against which the success or failure of specific groundwater protection strategies or interventions can be evaluated (e.g. compliance with environmental quality standards) and evaluation of those interventions (Quevauviller 2008).

6.2.2 Access and Allocation

Comprehensive, well defined, secure legal entitlements provide incentives for investment and collective water management (Ostrom 2005; Bruns et al. 2005). A distinction needs to be made between appropriation of groundwater for private use and provision of groundwater for public benefit. Water property rights give individuals an incentive to make the best use of groundwater for their individual purposes, but individuals do not have an incentive to provide groundwater for the environment or to take account of "external" impacts of their use on resources that are remote in space or time.

The collective allocation of entitlements to access and use groundwater is appropriate because of the common property nature of groundwater resources and the external impacts of their use. Collective allocation may be undertaken by elected governments or by other organisations that represent stakeholders, both water users and others. Access and allocation rules can be set out in legal documents such as in water plans, or more informally in local agreements (Tang 1992).

Water allocation describes the process that sets out how, by whom and on what basis decisions are made about access to and use of water (Turner et al. 2004). Water allocation processes take place on different sectoral and administrative scales. Allocation refers to both the allocation of groundwater, and also responsibilities and risks related to groundwater management. Clear allocation principles and priorities are particularly important to deal with water scarcities.

Groundwater allocation can be assessed in terms of its effectiveness, efficiency and fairness. Effectiveness is indicated by whether water allocations are sustainable and meet quality standards. Efficiency is indicated by whether groundwater is allocated or can be transferred to its most economically efficient use. Fairness is indicated by whether people and communities have access to water of acceptable quality to meet their needs. The allocation of groundwater access and use entitlements is complicated by variation in legal authorities across administrative boundaries, conflicts between competing users and uncertainties about future bio-physical and social conditions (Blomquist et al. 2004). The agriculture sector is the main user of groundwater in many countries, but many cities depend on groundwater. As agriculture develops and cities grow the access and allocation of groundwater becomes more challenging.

6.2.3 Accountability

Two important aspects of accountability can be distinguished. Democratic accountability refers to the institutions and procedures that provide public accountability for groundwater abstraction and groundwater quality standards. Technical accountability refers to processes of monitoring and reporting about groundwater condition and use. Both forms of accountability occur at multiple geographical and administrative scales.

Accountability and legitimacy issues have become increasingly important given the increasing complexity of groundwater management organisations, which include private actors and networks as well as elected governments. When central government agencies govern groundwater they are democratically accountable to the government of the country. However, centralised government agencies may be disconnected from water users and communities, who may perceive government decisions as not being consultative or legitimate (Gross 2011). When groundwater is governed by non-government bodies such as water user groups or watershed partnerships the lines of accountability are less clear. Such bodies may give disproportionate influence to particular groups such as farmers but may also offer opportunities for developing deliberative processes that are genuinely engage citizens (Huitema and Meijerink 2012).

Accountability requires the effective measurement and monitoring of groundwater use. This requires the installation of meters on individual wells and collation of use data by managing bodies – government or non-government. Measurement, monitoring and reporting of groundwater use is complicated by the large number and diffuse nature of groundwater users, and by the fact that many of the impacts of groundwater use only become evident after many years (Moench 2007). In many countries, the data available on both groundwater quantity and quality are poor and not standardised compared to the data available for surface water (Biswas 1999).

6.2.4 Adaptation

Adaptation can be encouraged by institutional design or implementation processes. Institutional adaptation allows for learning and change in response to unforeseen situations, such as unexpectedly severe droughts or floods, and changing knowledge and policy (Walters 1986; Pahl-Wostl 2007). Regulatory instruments and long-term plans provide direction and certainty to water users but they can be relatively inflexible in responding to change. Flexibility mechanisms such as adjustable shares of volumetric water entitlements, carryover arrangements, water trading and leasing have been built-in to groundwater regulations and plans in Australia and the Western USA to improve adaptability (Ross 2012).

Adaptation is also encouraged by collaborative groundwater governance processes that allow governments, water users and independent experts to collectively learn, negotiate and co-produce groundwater management arrangements (Emerson et al. 2012). It is not sufficient to get feedback through public seminars and discussions. Ongoing engagement of and effective collaboration between policy makers, scientists and practitioners is required (Letcher and Jakeman 2002).

6.2.5 Agency

A large variety of non-government as well as government organisations have been given authority to establish and implement groundwater policies and standards in different jurisdictions. Groundwater governance involves a large number of individuals and agencies exercising a wide range of roles and responsibilities. Groundwater governance has often been criticised as being too fragmented, including too many agencies with unclear roles and responsibilities. However attempts to streamline groundwater governance have proved difficult because of the wide diversity in groundwater resource and user attributes.

Groundwater governance poses a cross scale management dilemma. High-level governments can provide effective control, cross sectoral coordination and accountability, and can act flexibly to solve crises. However, hierarchical management can become very complicated at the river basin or sub-basin scale and may displace stakeholder and community action. Moreover, local governments and water users often understand groundwater resources and their importance to communities and the environment better than central governments (Ross 2012).

Special-purpose organisations, such as catchment management organisations in Australia and water districts in the USA may provide a better match with hydrogeological boundaries, better local coordination, and encourage engagement and innovation (Marshall 2005; Cech 2010). However, local organisations lack knowledge and incentives to manage intertemporal impacts of resource use at a river basin scale (Schlager 2007), and sometimes lack public accountability.

6.3 Groundwater Governance in Australia, the European Union and the Western United States

6.3.1 The Context for Groundwater Governance

Increasing groundwater use in Australia, the EU and the USA underlines the importance of good groundwater governance. Groundwater provides about 17 % of water used in Australia, and much higher percentages in some regions and/or during dry periods. Groundwater use is increasing rapidly. For example between 1993–1994 and 1996–1997 groundwater use tripled in New South Wales and Victoria, the most populous states in Eastern Australia (the Australian Government 2001). By 2030 average groundwater use in the Murray-Darling Basin – which includes the majority of Australia's irrigated agriculture, is estimated to increase from an average of 14 % to 27 % of the total water used (CSIRO 2008).

Groundwater supplies about 65 % of public water supplies in Europe (Jacques 2004), and 23 % of agricultural water. There are wide variations between the EU states with a much larger proportion of agricultural water coming from groundwater in southern Europe (EASAC 2010). In many rivers across Europe more than 50 % of annual flow is derived from groundwater, and in dry periods this can rise to more than 90 % (European Commission 2008).

In 2000 groundwater provided about 20 % of water consumed in the USA, 37 % of public supply withdrawals and 51 % of drinking water. There is substantial variation between the states, and in the arid Western USA there is substantial water scarcity, groundwater over drafting and related problems including land subsidence, saltwater intrusion and pollution. Groundwater use for irrigation has increased substantially. In 1950 only 23 % of irrigation withdrawals were groundwater, by 2000 groundwater's share had risen to 42 % (Kenney et al. 2009).

6.3.2 Key Elements of Groundwater Governance in Australia, the EU and the Western USA

Key elements of governance architecture, allocation and access, accountability, adaptation and agency in Australia, EU and the Western USA are summarised in Table 6.2 and described in the following sections of this chapter.

Table 6.2 Key elements of groundwater governance in Australia, the EU and the Western USA

	Australia	EU	Western USA
Architecture	National Water Initiative (NWI) Tradable property rights Water plans Drinking water standards	EU water framework directive (WfD) Groundwater quantity and quality standards River basin management plans	No national strategy Tradable property rights Augmentation/ mitigation plans Drinking water standards
Allocation and access	Return overallocated basins to sustainable use	Maintain good groundwater condition (quantity and quality)	Maintain property rights of senior (surface water) users – prior appropriation system
Accountability	NWI consultation principle National monitoring of NWI, State monitoring of water plans	WFD consultation principle Reporting on river basin plans	No national accountability except for drinking water standards
Adaptation	Variable "share" allocations Water markets	EU/National drought management plans Flexible implementation of WFD	Water "rationing" by means of prior appropriation system Flexible implementation of prior appropriation
Agency	Centralised governance	Subsidiarity principle Wide range of national settings	Emphasis on local governance by courts and water users monitored by States

6.4 Governance Architecture: Principles, Policies and Institutions

Australia and the EU have both adopted broad scale (continental) water management strategies with embedded groundwater components. The USA has not adopted a single comprehensive water management strategy and relies on a more decentralised approach using historical water allocation norms and principles – prior appropriation in the case of the Western USA. Groundwater governance in Europe is largely based on regulation, Australia has developed a mixed system of regulation and markets, the USA has a polycentric groundwater governance system with a mixture of instruments.

6.4.1 Australia

Groundwater management in Australia has been strongly influenced the trajectory of surface water reform. Principles for water governance in Australia are contained in the 1994 and 2004 Council of Australian Government (COAG) agreements on water reform. The 1994 COAG agreement included full cost recovery, separation of water from land titles, integrated catchment management and the establishment of water markets and trading (COAG 2004). The 2004 Intergovernmental Agreement on a National Water Initiative (NWI), included the establishment of secure water access entitlements, water access planning with provision for environmental and other public benefit outcomes, the return of over allocated systems to sustainable levels of extraction and further development of water markets, best practice water pricing and national water accounting.

Section 23 of the NWI provides for “a nationally consistent market, regulatory and planning based system for managing surface water and groundwater resources”, while 23 (x) recognises “the connectivity between surface and groundwater resources and connected systems managed as a single resource”. Surface water and groundwater for human consumption and the environment are managed within this framework but water quality is managed separately.

Under Australia’s federal system of government, the primary right to own or to control and use water is vested with the States and Territories (Lucy 2008). The States and Territories have enacted “mirror” legislation to incorporate the NWI in state laws and regulations. Groundwater is allocated in accordance with priorities established by the State governments. The 1992 Murray-Darling Basin agreement placed a cap on surface water use (MDBC 2006), and included a formula for allocating water among MDB jurisdictions, but there was no similar cap on groundwater use, which continued to expand for a further decade.

The Australian Government’s Water Act 2007 requires that the new Murray-Darling Basin Authority prepare an integrated surface and groundwater plan for the basin. The Basin Plan was passed by the Australian Parliament on 26 November 2012. The plan includes sustainable diversion limits for groundwater resources, but these have been criticised insufficiently recognising surface water groundwater connectivity and for failing to take account of environmental impacts of groundwater pumping (Nelson 2012).

Groundwater quality is not included as a central objective or element in the NWI. Water quality is subject to a separate agreements between Australian governments, including the National Action Plan for Salinity and Water Quality and the National Water Quality Management Strategy (NWQMS). The NWQMS contains detailed standards for water that is to be used for specific human consumptive purposes, which are included in state legislation, but groundwater quality monitoring is generally poor. Groundwater salinity is increasing and groundwater dependent ecosystems are threatened by over-extraction and poor groundwater quality in some areas. Nitrate levels in some irrigated catchments exceed national drinking water standards and ecosystem protection guidelines (Geoscience Australia 2010).

6.4.2 The European Union (EU)

The European Water Framework Directive (WFD) developed from a series of earlier water directives which were driven by concerns to ensure clean water supplies and to maintain environmental quality in the EU. The WFD is a legally binding policy that provides a common framework for integrated management of the quality of all types of water in Europe. The WFD came into force in December 2000.

The primary objectives of the WFD are to protect and enhance water quality and aquatic ecosystems and to promote sustainable water use. The WFD includes five key elements; river basin management based on river basin plans, a combined approach to pollution control linking emission limit values to environmental quality standards, definition of "good water status", the principle of full cost recovery for water and increasing public participation in policy making (Page and Kaika 2003). Good water status includes a focus on ecological status for surface water and quantitative status for groundwater i.e. groundwater levels linked to the achievement of ecological objectives (Wijnen et al. 2012).

The WFD is a supranational law which had to be transposed into domestic law of the EU Member States. Parts of the WFD, especially the chemical status of water bodies and the so-called priority substances contain specified standards. Environmental standards have been set for surface water for 33 substances. The ecological goal-setting process allows member states considerable freedom regarding both policy process and policy output, e.g. targets and end goals for water bodies. Implementation is flexible in several important ways including the designation of the relative "modification" of water bodies, the degree of formalisation of goals and environmental standards, scale of implementation, stakeholder participation, integration with other policy fields, and finally exemptions from general targets (Liefferink et al. 2011). If member states fail to transpose the WFD the European commission can initiate an infringement procedure before the European Court of Justice which may impose financial penalties (Mechlem 2012).

The WFD (Article 4.1(b) (i and ii) require member states to implement all measures necessary to prevent or limit the input of pollutants into groundwater, to prevent the deterioration of the status of all bodies of groundwater, and to protect enhanced and restore all bodies of groundwater, ensuring a balance between abstraction and recharge with the aim of achieving good groundwater status within 15 years.

Groundwater provisions of the WFD require member states to define and characterise groundwater bodies (within river basin districts), identify bodies at risk of not meeting WFD objectives, establish registers of areas where groundwater requires protection, establish groundwater threshold values (quality standards), pollution trends, and measures to prevent or limit inputs of pollutants into groundwater. Implementation of these provisions includes establishment of monitoring networks, and inclusion of groundwater protection in river basin management plans and programs of measures for achieving WFD objectives for each river basin district (European Commission 2008).

River basin management plans were due to be submitted to the Commission by 2009 and programs of measures have to be in force by the end of 2013. However, there are large differences between member states in the enforcement of EU standards. More than 50 % of groundwater bodies in some southern European states are at risk of not meeting WFP requirements because of the overpumping and pollution (EASAC 2010).

6.4.3 Western USA

There is no overarching national strategic framework for water management in the United States or across the western USA. Water for human use and the environment, and water quantity and water quality objectives are managed separately. Each individual state has "plenary control" over the waters within its boundaries and state of local governments set goals for regulating water use and water pollution.

In the Western USA the doctrine of prior appropriation was developed to set water allocation priorities and to address disputes among landowners. The doctrine includes four key elements; establishment of a water right by diverting water and applying it to a beneficial use, and (once beneficial use was established) the right to exclude others from using the same water, to use the water in allocation distant from the source and to sell the water to third parties (Jones and Cech 2009). Subsequently most western states adopted groundwater legislation that extended the doctrine to cover groundwater (Schlager 2006).

State law underpins the doctrine of prior appropriation (Kenney et al. 2005). If low stream flows prevent senior rights holders from diverting the water to which they are entitled, the seniors put a "call" on the river, requiring all upstream rights holders "junior" to the caller to stop diverting water until adequate streamflow is restored (Howe 2008). In the prior appropriation system most groundwater rights holders are relatively junior and have to make good their impacts on senior rights holders. In times of water scarcity this can result in groundwater pumping being terminated (Jones 2010).

Groundwater drawdowns and pollution have led to the choice between reducing the take of existing users or restricting new development. In some cases groundwater users have successfully lobbied against restrictions leading to the ongoing depletion of resources such as the High Plains aquifer (Sophocleous 2009).

The US Federal government has had a strong involvement in water development and distribution, through major water projects and more recently through federal environmental law (Kenney et al. 2005).

The Federal Clean Water Act (s102) provides for the development of comprehensive programs for preventing, reducing or eliminating the pollution of groundwater used for human consumption. The Act (s106) also allows for funding to support groundwater protection programs but in practice the costs of remediating source water pollution are met by municipal governments and industry (GWPC 2007). Federal pollution control laws including the Resource Conservation and Recovery Act and the Comprehensive Environmental Response Compensation and

Liability Act provide for landowners to be liable for point source pollution including impacts on groundwater (Smith 2004). The Endangered Species Act provides for the conservation of threatened and endangered plants and animals and their Habitats, and is an important driver for environmental water provision.

Application of prior appropriation to groundwater has not prevented groundwater depletion in unconnected basins, while in connected basins it has prevented the use of groundwater when surface water is scarce (Schlager 2006), Groundwater quality controls are largely limited to point source pollution and sources of drinking water, there are no systematic controls on diffuse pollution. Thomas (2009) argues that the US would benefit from the adoption of a federal approach similar to the EU groundwater directive to protect its groundwater resources.

6.5 Access and Allocation

6.5.1 Australia

Under the NWI Australia has adopted a framework of water entitlements that are completely and transparently defined, separated from land wherever possible, specified in registers, monitored and enforced (NWC 2009). Entitlements to access water, to take water in a particular season/year and to use water at a particular place and time for a specific purpose are separated from land ownership.

Surface water allocations are made to satisfy these entitlements in each season/year as defined in the relevant State water plan and depending on the amount of water available. During scarcities lower priority agricultural uses receive less than the face value of their water entitlement. In most Australian jurisdictions the separation of water entitlements from land promotes the development of water markets and trade in water.

The allocation of shares of total available groundwater is more difficult to clearly define. Groundwater availability is often defined according to proportion of long-term recharge that can be extracted without compromising the integrity of the water source and the ecosystems and communities that depend on it.

The use of groundwater has been restricted in a limited number of management areas on the basis of exploitation of, or stress in surface and/or groundwater resources. In some highly exploited stressed groundwater systems, annual allocations of a share of water entitlements have allowed authorities to control groundwater exploitation without compulsory reduction of entitlements (NWC 2006). Cease to pump rules are applied to some groundwater resources to maintain minimum flows in connected streams. However, there is no systematic national approach.

The efficient allocation of resources has been boosted by the development of water markets but the effectiveness of the protection of groundwater resources is complicated by the overallocation of water use entitlements (Young 2010), and the failure to properly account for impacts on groundwater use of surface water resources (Evans 2007). There are a range of community perceptions about fairness in water allocation, in particular there is some disagreement about the balance of allocations between water for the environment and irrigation (Connell et al. 2007).

6.5.2 The EU

In the EU the entitlement to use water is generally given by public authorities through licences and permits. Water allocation is carried out by different authorities and agencies at different levels. Authority to pump groundwater is generally given through permits that refer to the quantity of water abstracted and/or pumping capacity. Permits are issued for varying periods of time in different states. In some states including France, Germany and the UK environmental impacts are considered when granting permits.

National authorities have powers to restrict abstractions during times of water scarcity or drought. Some countries such as Netherlands, Spain and France determine restrictions according to a hierarchy of water users. Priority may also be given to particular sectors, or sometimes within sectors, for example for specific crops (European Commission 2012).

Also the WFD sets a "good quantitative status" for groundwater which implies an obligation to ensure a balance between (natural) recharge and abstraction over a river basin management cycle. However, the implementation of the programme of action that has followed the groundwater directive has concentrated on water quality issues rather than over abstraction.

Regulation of groundwater has not kept pace with the rapid growth in groundwater use in terms of both users and volumes used. Different member states use different combinations of instruments to manage groundwater resources. In some parts of the EU land-use control is the main instrument. For example in the UK environmental agencies have defined source protection zones for some 2000 groundwater sources. In many parts of the EU there are regimes for groundwater protection including the licensing of boreholes. However, in many of the southern European states the number of unlicensed users is growing rapidly (EASAC 2010).

The effectiveness of the Water Framework Directive is being reduced by slow implementation because of the different degrees of ambition and cohesion of the efforts of member states (Liefferink et al. 2011), and technical challenges including information processing (Hering et al. 2010). In southern Europe where the economic and social dependence on groundwater takes precedence over ecological considerations a difficult balance has to be struck between the social benefits of current consumption and the broader social and ecological benefits of conserving water dependent ecosystems (EASAC 2010). European water markets for quality or quantity are not well developed, reflecting a European emphasis on administrative water allocation and regulations on water quality. These institutions may be relatively efficient for European conditions, but there are opportunities for markets that can deliver greater amounts of cleaner water at lower costs (Zetland 2011).

6.5.3 The Western USA

In the Western USA groundwater access and allocation has been regulated by the operation of the prior appropriation system. Water access and allocation reflects common-law courts decisions from the late 19th and early twentieth century. Surface water rights are generally senior to groundwater rights.

Prior appropriation has worked differently when applied to aquifers compared to surface waters. It has also applied differently to groundwater resources unconnected to surface water (non-tributary) and connected (tributary) resources (Schlager 2006).

In the case of non-tributary groundwater priority acts to limit the number of well permits issued but does not prevent declining water tables. Reasonable declines in water tables are allowed. It is up to state courts to determine what constitutes a reasonable decline on a case-by-case basis. State governments have not intervened to limit the issue of well permits until aquifer depletion and/or negative impacts on other users have become serious. In the case of tributary groundwater, prior appropriation has been adapted to allow some groundwater pumping while protecting senior surface rights. Groundwater pumpers have been allowed to pump water if they can provide water to augment stream flows to prevent injury to surface water users (or the environment). This system prevents long-term over abstraction of tributary groundwater, but it can discourage efficiency because water is forfeited if it is not used within the statutory time period (Neuman 2010) and it prevents the use of groundwater during droughts when it is most needed (Schlager 2006).

Further modifications of state water allocations based on prior appropriation have been needed to allow for the fact that hydrologic systems do not stop at state boundaries (GWPC 2007) and pumping can harm senior water rights in adjoining states. In order to deal with this problem interstate agreements have been negotiated to address cross-border impacts of water use.

Environmental water allocation is managed separately from water for consumptive use and the fairness of the prior appropriation system can be challenged in the sense that it does not service changing social preferences such as environmental water requirements. Federal environmental laws including the Clean Water Act and the Endangered Species Act provide the main driver for environmental water provision, often through an interstate compact. For example, the South Platte Compact requires that between April 1 and October 15 Colorado must ensure river flows do not fall below 120cfs.[1] Colorado has also committed to making 10,000 acre feet of water available between April and September of each year to assist recovery programs for three endangered birds and one endangered fish (Freeman 2011).

[1] 100 cubic feet per second equals 2.82 cubic metres per second.

6.6 Accountability

6.6.1 Australia

In Australia there are several levels of democratic accountability for groundwater management. The National Water Commission (NWC) has responsibility for reviewing the implementation of the NWI and reporting to the Australian government. The NWC has published biennial reviews of the NWI. State and Territory water authorities have responsibility for establishing groundwater management plans, and monitoring and enforcing these plans. These authorities report progress to their own government and also to the NWC.

The NWI provides that governments engage water users and other stakeholders in water planning and other reform processes in order to improve certainty and confidence, transparency and information sharing. State water legislation includes provision for consultation in relation to water plans, but consultation often appears more symbolic than real, because it takes place after policy changes have been made and/or does not take sufficient account of stakeholder views (Bowmer 2003). Australian and international experiences show how communities can use collaborative water planning processes to manage cuts to water allocations (Richardson et al. 2011) and for flood and drought risk management (Daniell et al. 2010).

The NWI requires all jurisdictions to ensure adequate measurement, monitoring and reporting systems are in place. The capacity of State and Territory governments to monitor groundwater resources and plans is mixed. Some resources, especially the most highly exploited resources, have relatively good metering and monitoring, but many resources lack basic metering, measurement and monitoring infrastructure. There is a national program to develop this infrastructure. Monitoring of groundwater quality is limited and carried out in an ad hoc manner. There is no consistent national program on groundwater quality monitoring and much of the monitoring has been short term (Geoscience Australia 2010).

6.6.2 The EU

Democratic accountability for the implementation of the WFD is complex with local areas reporting to national governments and parliaments who in turn report to the European Community and Parliament. EU member states and the European commission have jointly developed a Common Implementation Strategy (CIS) for supporting the implementation of the WFD. A Strategic Coordination Group (SCG) composed of Member States and stakeholder organisations coordinates cooperation on implementation.

Groundwater planning and allocation systems have high levels of democratic accountability to national governments, and the European Parliament, but sometimes are not perceived as legitimate at local levels because of lack of community participation and deliberative processes. The WFD requires governments to provide information about planned measures and to report on implementation to stakeholders and the general public. It remains a challenge to ensure public access to reliable and consistent information about measures, and to motivate and facilitate public participation (De Stefano et al. 2013).

The SCG has developed guidance documents on groundwater monitoring and groundwater protected areas and is developing guidance on compliance and impacts of land use on groundwater. Measurement, metering and monitoring capability varies substantially among the EU member states, and between regions within the states. EU wide coverage and long-term series of water quality data are not available, and the analysis of water quantity is insufficient in many river basin plans – only 25 % of plans include water availability scenarios and less than 20 % assess data uncertainty.

6.6.3 Western USA

State governments are accountable for groundwater management. There is no national accountability mechanism except in the case of transboundary aquifers where there are interstate agreements, and where federal courts or the Supreme Court are responsible for the agreements.

Water management in the US is fragmented, with many overlapping jurisdictions and agencies. Stakeholder engagement, information sharing and accountability is effective across parts of the system but it is very difficult to ensure good communication and consultation across the whole system. Groundwater is governed by a network of water users, water courts and administrative authorities. Groundwater management arrangements are accountable and are perceived as legitimate at a local level, but are not necessarily democratically accountable or perceived as legitimate at a broader level.

There are many gaps in information about groundwater availability and use and there is a need to improve the effectiveness of coordination of groundwater information and data. There is no regular national review or monitoring of groundwater use. The US Geological Service issues periodic reports. The latest covered groundwater use in 2010 (Maupin et al. 2014).

The Clean Water Act (s 106(e)) requires the USEPA to determine that a state is monitoring water quality including groundwater. Thirty states have included some groundwater monitoring in their water monitoring strategies but most of the emphasis is on surface water monitoring.[2] From 1991 the US Geological Survey (USGS) has implemented a National Water Quality Assessment Program that includes groundwater assessments. The USGS has identified 62 regionally extensive aquifers and is carrying out assessments of about one third of them, but most aquifer assessment and monitoring is carried out by the states, and the quality of the programs is highly variable (GWPC 2007).

[2] GWPC-NGWA survey of State groundwater programs, 2006.

6.6.4 Monitoring – A Common Challenge

Australia, Europe and the Western USA face similar technical accountability challenges because of shortfalls in groundwater metering and monitoring infrastructure. It is difficult to centrally manage groundwater monitoring because groundwater abstraction is very diffuse. On the other hand groundwater users and local governments often have insufficient mandate or resources to put broadscale monitoring programs in place.

6.7 Adaptation

6.7.1 Australia

Section 25 (iv) of the NWI provides for adaptive management of surface water and groundwater systems in order to meet productive, environmental and other public benefit outcomes. The National Water Commission undertakes biennial reviews of the implementation of the NWI, but it is left for states to determine how often to review water plans in their jurisdictions. Under the new Murray-Darling Basin plan the Murray-Darling Basin Authority will review state water resource plans, which will usually have a 10 year life cycle.[3]

In the Murray-Darling Basin flexibility is introduced into water allocation in three ways. Firstly water is allocated to entitlement holders on an annual basis depending on water availability. Secondly surface water and groundwater entitlement holders have a limited capacity to carryover water entitlements for later use. Thirdly, surface water and groundwater trading provides some extra flexibility for water users, including the potential to purchase additional water to make up shortfalls in allocations during dry periods, if there is water available for purchase. However, groundwater trading volumes have been relatively small in the Murray-Darling Basin and there has been no recorded surface water and groundwater trading (Ross 2012).

6.7.2 The EU

The EU WFD adopts an adaptive water planning approach. National water authorities adopt management plans, including quality standards and programs of measures for water districts for 6-year periods. These plans are monitored and evaluated and the WFD recognises that quality standards and programs of measures may need to be modified in the following 6-year period. However, the legal systems of some member states are not sufficiently flexible to respond to new situations and information.

[3] http://www.mdba.gov.au/draft-basin-plan/delivering-healthy-working-basin/ch03. Accessed 5 April 2013.

The WFD recognises the importance of adaptive mechanisms but they are dealt with through parallel processes including the EU water scarcity and drought policy developments. In 2007 the European Commission released a communication on water scarcity and droughts that laid down a water hierarchy including demand management followed by alternative supply options once the potential for improving water efficiency had been exhausted. This text is, however, not legally binding.

A Commission review of this policy (European Commission 2012) found that while member states have established mechanisms for authorising groundwater use, illegal abstractions remain an important challenge in some parts of Europe. There has been only limited implementation of drought risk management plans, and cost recovery and price incentive mechanisms.

In practice the main flexibility mechanism in the WFD is the degree of freedom given to member states to set groundwater standards and implementation timetables. This approach reflects heterogeneity in the member states, but could result in slow improvements in standards which would reduce the effectiveness of the WFD.

6.7.3 Western USA

The prior appropriation system deals with uncertain water supply and shortages by setting clear priorities for allocation of scarce water based on seniority. Junior water entitlement holders must relinquish water in times of shortage. This system provides certainty in the face of changing water supplies but is not very flexible in responding to changing social preferences for the use of water such as demand for new urban development, provision for in stream flows or conjunctive water management. In addition conflicts are resolved by litigation which can be slow and not very responsive to unanticipated crises needing urgent responses.

Adaptive management is gaining a foothold in some agencies like the National Marine Fisheries Service and the U.S. Forest Service, but state water management agencies have a restricted role and responsibilities, to manage the allocation of water for consumptive use or to control water to ensure consumptive supplies. Water quality and water for the environment are managed separately. Because of these management settings water management agencies are not at the forefront of strategic adaptive management (Neuman 2010), although they do provide some leadership in information collection, monitoring and the development of local water allocation plans (Wolfe 2008).

In practice the law of prior appropriation has included provisions for reducing allocations of water to users in response to risks including water scarcity, wasteful or non-beneficial use or displacement by "public rights". On the other hand junior entitlement holders including municipalities and groundwater groups have obtained enough political power to secure continued allocations (Tarlock 2001). For example, local water plans in Colorado have enabled flexible implementation of the prior appropriation system, without requiring junior groundwater entitlement holders to cease production, except in the most extreme drought conditions (Blomquist et al. 2004).

Water trading and leasing provide further flexibility mechanisms. In Colorado there is a significant amount of water trading, mainly transfers from agricultural to municipal users (Howe and Goemans 2003). Water leasing has enabled farmers to lease part of their water portfolio to municipalities and to reduce their acreage temporarily through crop rotation or fallowing (Pritchett et al. 2008).

6.8 Agency

6.8.1 Australia

Historically, surface water and groundwater planning, rule development and administration have been separated in Australian jurisdictions. The historical separation of surface water and groundwater science (hydrology and hydrogeology) has reinforced the administrative separation. These separations have hindered the development of integrated water management. Water management and allocation in the Australian states is highly centralised in the hands of responsible ministers and their departments. Surface water and groundwater policy and planning are coordinated at the highest levels of decision-making, but often separate at lower levels.

Government representatives generally consider that policy and implementation functions are integrated effectively. But some water users consider that state water managers do not provide enough information and that some functions are poorly integrated. For example, in the Namoi region in New South Wales, users cited as examples of poor integration the separation of management of overland flows, stock and domestic bores, and issues related to water in the mining sector from other water planning and allocation processes. Local and regional bodies could play a more effective role in water planning and management if there were increased delegation of responsibility to these bodies, increased funding or fund raising capacity and support from high level leadership.

6.8.2 The EU

The EU Water Framework Directive initiated the move from national and local water management towards river basin planning, but generally EU member states adapted existing management and administrative bodies to implement the WFD maintaining long-standing water management institutions.

Groundwater governance in Europe is generally coordinated by national authorities, sometimes concentrated at the level of member states and sometimes decentralised to regional and local levels. There is a large diversity of management organisations. Many small states such as Denmark have a relatively top-down approach, whereas the large states exhibit a greater diversity of multilevel governance agencies. In Denmark the Minister for Environment is responsible for river basin management plans, whereas in the Netherlands the competent authority is the Minister for Transport, Water Management and Public Works. In the Netherlands regional water authorities and water boards have a strong role in implementing the WFD.

River basin authorities have a leading role in a small number of member states. France had already adopted a river basin approach before the WFD was conceived and adapted the existing structure of the river basin and sub-basin plans to implement the WFD (Liefferink et al. 2011). Water user groups play an important role in a limited number of countries including Spain. European countries will benefit from continued experiments with groundwater governance and representation from different levels of government, water users and experts.

6.8.3 Western USA

Federal water-related agencies and programs are fragmented and require better coordination. More than 30 federal agencies, boards, and commissions in the United States have water-related programs and responsibilities (Christian Smith et al. 2012). The allocation and distribution of water is subject to regulation by state water resource agencies, and is ultimately in the hands of thousands of farmers, hundreds of irrigation districts and a large number of municipalities and industries.

Local groundwater supply and distribution is managed by regional and local water entities, such as mutual water user companies and cooperatives, irrigation districts, conservancy and conservation districts. These organisations provide a crucial link between state laws and policies and individual water users. In some states water districts play an important role in encouraging regional coordination and innovation. In most cases organisation members democratically establish policy and elect management Boards. The organisations are non profit and raise revenue by assessments on shares (mutual companies), on acreage allotments (irrigation districts), or taxes on land or water sharing assessments (conservancy districts) (Freeman 2000). Municipal users and irrigators initiated the South Platte Water Related Activities Program to ensure that instream flow and endangered species obligations are met (Freeman 2011).

Decentralised groundwater management in the Western USA has encouraged many institutional innovations but management effectiveness could be could be improved by strategic watershed planning that integrated consumptive and environmental requirements, and gave governments and water users an opportunity to adjust the prior appropriation doctrine in order to achieve improved water management outcomes.

6.8.4 The Influence of Vested Interests

In all three regions historically powerful water authorities and water users exert substantial influence and sometimes resist change. The protection of groundwater dependent ecosystems is an ongoing challenge. Strong leadership and broad community engagement are needed to progress reforms in groundwater management.

6.9 Comparative Assessment of Groundwater Governance in Australia, the EU and the Western USA

Drawing on the analysis in the previous section the main strengths and weaknesses in groundwater governance in Australia and the EU and the Western USA are summarised in Table 6.3.

Table 6.3 Strengths (+) and weaknesses (–) of groundwater (GW) governance in Australia, the EU and the Western USA

		Australia	EU	Western USA
Architecture	+	NWI provides for comprehensive GW governance	WFD provides comprehensive GW protection	Prior appropriation system safeguards senior water rights
	–	Weak GW quality regulation (except for drinking water)	Variable implementation of GW standards	Weak GW quality regulation (except for drinking water)
Access and allocation	+	Water plans set sustainable GW use limits	GW allocation included in river basin plans	Effective rationing of scarce water
	–	Overallocation of GW use entitlements	Variable implementation of basin plans	GW overuse in some areas
Accountability	+	Democratic legitimacy	Democratic legitimacy	Local legitimacy
	–	Use monitoring variable, quality monitoring poor	Variable monitoring and reporting	Accountability for impacts at large scales, variable monitoring
Adaptation	+	Variable annual water allocation	Flexible implementation of EU standards	Local innovation, flexible enforcement of prior appropriation
	–	Centralised system can discourage local innovation	Slow implementation of drought management plans	Rigidity of prior appropriation during droughts
Agency	+	Central coordination and planning	Central coordination and planning	Local empowerment and innovation
	–	Local delegation and implementation	Local delegation (in most countries)	Strategic planning

The EU WFD has gone furthest towards an integrated framework to manage groundwater quantity and quality objectives and human and environmental uses of groundwater. The discretion for member states to set their own standards and implementation timetable provides flexibility but also threatens to undermine effectiveness of the WFD. Australia's comprehensive system of water entitlements and related water markets together with annual adjustment of entitlement shares provides security and flexibility for consumptive users and encourages efficient water allocation. But it is not yet clear how successfully environmental water allocations can be integrated within this framework. The system of prior appropriation in the Western US provides clearly defined priorities for water allocation, but lacks flexibility during extreme droughts. Neither the Australian nor the US systems effectively protect groundwater quality or groundwater dependent ecosystems.

Australia, the EU and the Western USA face common groundwater governance challenges. Firstly, the effectiveness of policy and plan implementation varies substantially within the regions. Secondly, there are substantial knowledge gaps, measurement and monitoring is expensive and is highly variable. Thirdly, powerful stakeholders conspire to prevent change when it threatens their interests.

6.10 Some Groundwater Governance Difficulties and Dilemmas

Experience with groundwater governance in the EU, Australia and the Western USA raises some unresolved dilemmas relating to relationships between aspects of groundwater governance.

Is a Comprehensive Integrated Groundwater Governance Architecture Feasible or Desirable?

A comprehensive system of groundwater governance would integrate the management of groundwater quantity and quality for consumptive and environmental purposes. Only the EU WFD attempts to integrate all four elements. This has proved to be an ambitious goal, and in practice full integration has not been achieved. In Australia the management of groundwater quantity and quality is carried out by separate institutions and in the Western USA all four elements are separated, with variable degrees of coordination in different regions. Degrees of separation of the four elements may be acceptable providing that there are effective coordination mechanisms, which raises the question of what those mechanisms would be.

What Coordination Arrangements Are Appropriate for Groundwater Governance?

Groundwater governance involves some particular coordination challenges. Firstly, groundwater resources and user groups are very diverse. Different management rules are appropriate for different resources and users. For example different rules will be appropriate for a shallow alluvial aquifer highly connected to a river compared with a fractured rock aquifer remotely connected with surface water. Secondly, the boundaries of groundwater resources, their flows and their interactions with surface water and the environment are often not well understood. Hence centralised groundwater governance can be very complicated, and groundwater governance is typically organised at multiple geographical, sectoral and jurisdictional scales. A multilevel groundwater governance model including elements of central control and accountability, together with decentralised, participative local agencies is discussed below.

Thirdly, long-term coordination raises special difficulties. The impacts of groundwater use on other resources and the environment can be delayed by many years, decades or even centuries. When long-term impacts are discounted using a "market" discount rate long term impacts have a negligible value. This implies that long-term impacts of groundwater overuse will be considered relatively unimportant compared to short-term impacts, and the maintenance of long-term stocks of groundwater will be considered less important than preserving jobs and environmental icon sites. If discount rates were chosen by means of a deliberative process involving commercial developers, community representatives and user groups as well as governments chosen rate could be lower (or higher) than the average market rate. Community discounting is not the current practice and could be expensive but it could better reflect community views and aspirations for the future (Ross 2012).

How Can Central Control and Stability Be Balanced with Adaptiveness?
Well defined, secure entitlements and rules about the use of groundwater increase confidence in and support for groundwater management. At the same time mechanisms that allow the flexible use, storage and exchange of groundwater over time are required to optimise groundwater use in response to changes in climatic and market conditions and new knowledge. There are some working examples of arrangements that combine security and flexibility. The allocation of tradable water entitlements coupled with annual calculation of water available to be used by water entitlement holders has proved to be an effective means of responding to drought in Australia, but requires the prior issue of individual tradable water entitlements – without overallocation. The wide variety of innovations introduced by water districts and communities in the Western United States show the potential for decentralised collaborative groundwater management, although these institutions may lack broad democratic accountability.

How Can Central Direction Setting and Coordination Be Balanced with Local Agency and Responsibility for Groundwater Governance?
In practice groundwater governance is typically polycentric, involving a network of governments and their agencies, and special purpose organisations. Participation by groundwater users in decision making is necessary to ensure that users understand each other and have the opportunity to craft mutually acceptable management arrangements taking account of relevant information and uncertainties (Emerson et al. 2012; Ross 2012). This can be achieved by a multilevel approach including both jurisdictional and/or basin wide overviews of water resources and uses and

detailed management arrangements for individual resources. This multilevel approach can avoid the difficulties involved in drafting and communicating a fully detailed management plan at the river basin or jurisdictional scale, but at the same time ensure a coordinated approach to water management consistent with broader social and policy goals. Higher level governments will need to overcome their reluctance to give control to decentralized organisations (Marshall 2005; Ross 2008).

6.11 Conclusions

In this chapter groundwater governance in the EU, Australia and the Western USA has been compared using an analytical framework drawn from the Earth System Governance Project. While the high-level international comparison yields some interesting results, the analysis masks many regional and local variations in the study regions.

The EU WFD has gone furthest towards an integrated framework to manage groundwater quantity and quality objectives, but there are many implementation challenges. Australia's system of water entitlements and water markets coupled with variable annual water allocations provides security and flexibility for consumptive users. But neither it nor the US system protect GDEs or prevent diffuse pollution of groundwater. While the US system provides clearly defined priorities for water allocation, it lacks flexibility during extreme droughts.

Fully integrated management of all sources of water, as intended by the WFD, is a very ambitious goal. The advantages of a strong central direction and coordination together with decentralised local management might be obtained through collaborative planning and management at sub-basin scales nested within an overarching groundwater planning framework at the jurisdictional or basin scale. This system could take various forms in different countries depending on social preferences and institutional settings and capacity.

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