# Water Markets in Federal Countries: Comparing Coordination Institutions in Australia, Spain and the Western USA

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**Abstract.** Water markets are a form of decentralized resource allocation, yet their success often depends on strong coordination institutions to establish appropriate regulatory frameworks, address disputes and minimize third party impacts as water is redistributed. Water markets and associated institutional reforms are prevalent in countries with federal political systems. The territorial division of authority in federal countries enhances representation of diverse interests and creates incentives for local innovation but it also creates potential coordination challenges in river basins shared by multiple jurisdictions. This paper compares water markets and associated institutional reforms in Australia, Spain and the Western USA - three federations with longstanding experience with water markets but different approaches to distributing authority and intergovernmental coordination in water allocation. We conduct an institutional mapping of national and sub-national roles in market-based water allocation reforms across the three countries and employ process tracing techniques to examine coordination challenges and institutional responses associated with water markets. The comparative institutional analysis illustrates how the policy goals addressed by water markets vary across – and within – the three countries in part due to the level of centralisation and the different balance of national versus sub-national interests driving water market development. Despite these differences, all three cases show that water markets require well-developed inter-governmental coordination institutions, which come in multiple forms matched to the local context, history and specific regional governance challenges.

Keywords: Water Markets, Federalism, Coordination Institutions, Murray-Darling Basin, Spain, Western USA

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# Introduction

Severe droughts and intensified competition for water have prompted interest in water markets as a means of reallocating water for cities, agriculture, energy production and ecosystems. The politics, institutional development and performance of water markets have been extensively studied and debated (Easter et al. 1999; Grafton et al. 2011; Maestu 2013). Economists have modelled the potential economic gains from trade (Qureshi et al. 2009), as well as the potential for transaction costs to negate them (Pujol et al. 2006; Garrick et al. 2013). Increasingly these studies point to the need for 'integrated water markets' that include strong institutional foundations (Grafton et al, 2011; Wheeler et al, 2017), attention to equity issues and environmental implications, and the development of coordination institutions (Howe et al. 1986). Strong institutions and governance are needed due to the politics of cap-and-trade water allocation (Heinmiller 2009) and the socio-political implications of water redistribution (Hernández-Mora & Del Moral 2015). The need for strong coordination institutions is expected to be highest when water rights are traded across political or basin boundaries (Young et al. 2000).

Despite the extensive body of literature on water markets and the increasing focus on their institutional foundations, limited attention has been paid to the role of scale, and specifically the intergovernmental coordination challenges associated with market-based reallocation. Water markets are closely associated with decentralized environmental and resource governance, yet their success is expected to depend on strong coordination institutions to establish appropriate regulatory frameworks and address disputes across sectors and jurisdictions (Garrick 2015, Casado-Perez 2016). This study fills a gap by examining intergovernmental coordination challenges associated with water markets and assessing the evolution and effectiveness of institutional responses to these challenges. These coordination challenges are pronounced in federal political systems, which divide authority between territorial (sub-national) and national governments, combining 'self-rule' by state governments with 'shared rule' by the states and federal levels (Elazar 1987).

The paper compares water markets in federal countries by examining the central versus state (sub-national) government roles in the design and evolution of water markets and how they are coordinated. It seeks to answer two specific questions relevant to water allocation and regional governance in federal political systems:

1. How has the distribution of authority within federal countries affected the goals, institutional reforms and implementation of water markets?
2. What are the intergovernmental coordination challenges associated with water markets, and how have institutions responded to these challenges?

The next section establishes a link between the literature on water markets and the literature on water governance in federal political systems to guide the comparative analysis. The third section outlines the methodology for selecting, developing and comparing the case studies on water markets in Australia, Spain and the USA, drawing on trading data, institutional mapping and process tracing techniques. Fourth, we examine the case studies in terms of the distribution of authority, coordination challenges and institutional responses in water market reforms and implementation. Finally, we compare the cases on these dimensions to distil

lessons about the evolution and effectiveness of water markets and coordination institutions in federal political systems.

## Water Markets and Federal Political Systems: An Analytical Perspective

There is an extensive literature on both water markets and water governance in federal political systems; however, there is much less attention to the intersection between the two. The territorial distribution of authority in federal political systems can incentivize local innovations, enhance representation of diverse interests, and tailor water rights systems to local conditions; however, it can also lead to fragmentation, and poses coordination challenges for water resources governance that affect efforts to design and implement market-oriented reforms (Garrick and De Stefano 2016). We focus on institutional responses to these coordination challenges. Ostrom defines institutions broadly as 'the prescriptions [including rules and norms] that humans use to organize all forms of repetitive and structured interactions' (Ostrom 2005: 3), which therefore transcends the functions of any specific agency or body. Here, we focus specifically on the role of *formal* and *inter-governmental* coordination institutions and emphasise their role spanning political borders and levels of government (Feiock 2013).

This section establishes the analytical approach for comparing the three case studies in terms of: the distribution of authority, coordination challenges and accountability issues affecting water markets.

First, the **distribution of authority** between national and sub-national governments is a fundamental institutional design consideration in federal political systems (Bednar 2008). Principles of democratic governance vest authority at the lowest level possible. Water markets involve a set of institutional reforms to water planning (establishing caps), water rights systems (allocating tradable water rights) and regulation (setting trading rules), which vary according to the distribution of authority in federal systems of water governance. Three broad approaches to water allocation in federal political systems have been identified, ranging from decentralised approaches to water governance (exemplified by Canada, the USA and India), centralized approaches (exemplified by Mexico and Spain) and mixed approaches (Australia) (Garrick and De Stefano 2016). The three key institutional reforms of water markets – capping, creation of tradeable entitlements, and trading rules (Heinmiller 2007) – are carried out at different tiers of governance – the state or national level – based on the type of federation, and its institutional arrangements for governing water. When river basins cross sub-national and international borders, basin-scale and/or interstate coordination may be necessary for addressing cross-border externalities.

Second, federal systems of water governance require **intergovernmental coordination institutions** to foster cooperation and resolve conflicts between sectors and jurisdictions that share water resource systems (Gerlak 2006). Historically, the apportionment of water among jurisdictions sharing a river has been a flashpoint for conflict, while the development and operation of basin-wide storage and distribution infrastructure creates both potential for conflict and cooperation opportunities (Wheeler et al, Benson this issue). Water markets involve several coordination challenges associated with institutional reforms and trading

activity, when reallocation has distributional consequences with disproportionate impacts on specific jurisdictions (Kenney 2013, Young et al. 2000).

Despite growing recognition of the importance of coordination institutions in water markets, there is still limited understanding of their form and function within and across different political contexts. Meinzen-Dick (2014) differentiates property rights from the coordination institutions used by to manage and exchange property rights; there are three *ideal types* of coordination institutions, including the state, self-organisation by resource users or the market, which are often mixed in practice. She emphasises that coordination institutions become more important and often more formal as collective action challenges span longer and larger scales, yet there has been limited analytical clarity and precision about the types of institutional arrangements used for transboundary coordination in water markets. Here we focus on institutional responses to coordination challenges in the context of federal political systems, which involves institutional arrangements to facilitate cooperation and conflict resolution across multiple states (horizontal coordination) and tiers of governance (vertical coordination). Intergovernmental coordination institutions can vary in their scope (single versus multi-function) and authority (informal versus formal) (Feiock 2013). In the context of water markets, intergovernmental coordination institutions range from single function to more encompassing arrangements, including:

- conflict resolution venues (particularly courts),
- fiscal arrangements (cost, risk and benefit sharing between states and the state and federal governments),
- planning venues (e.g. councils of governments) to develop inter-governmental agreements,
- monitoring and data sharing arrangements, and
- basin organisations which facilitate coordination across multiple functions and implement decisions

In some cases, one entity (a basin organisation) carries out all of these coordination roles; in other cases, coordination is more fragmented across multiple institutional arrangements. We expect that the level of centralisation and the nature of the federation can have a direct bearing on the type, structure and performance of the intergovernmental coordination institutions in place.

Finally, water trading and associated institutional reforms in federal political systems depend on **accountability and transparency** of coordination institutions to enhance the legitimacy of water markets. Accountability in the development and implementation of water markets requires transparency in data sharing and decision-making. State governments, river basin organisations and federal agencies therefore play a critical role in establishing water rights registries, ensuring inclusive planning processes and disclosing data about trading and its impacts. The politics of planning, measurement, monitoring and disclosure are highly contested, however. Irrigation communities and water brokers have resisted such disclosure practices due to perceived risks of losing water rights or the potential for increased charges for

operations and maintenance costs (Colby 1990, Birkenholtz 2016). Asymmetries in information, where water users have more knowledge than regulatory bodies about historic patterns of water use, may strengthen bargaining positions, weaken enforcement of water rights and undermine protections for third parties, the public and the environment. In a multi-level and multi-jurisdictional context, there can be little incentive for being transparent when there are different levels of governance that benefit from the status quo, or when power dynamics make information a strategic resource in water allocation.

# Methodology

## Case study selection

We compare the politics and institutional development of water markets in three countries with federal or quasi-federal political systems: Australia, Spain and the Western USA. These three case studies were chosen for two reasons. First, they have at least 15 years of experience with water markets and associated institutional reforms. Second, the three countries vary in terms of their level of centralisation in water allocation and basin planning. At one end of the spectrum, Spain has a centralised approach to water legislation, with river basin authorities having responsibility for water planning and allocation for rivers that cross state boundaries , whereas states[1] have authority over intra-state river basins. At the other end of the spectrum, the Western USA vests allocation authority at the state level with federal roles limited to the financing and management of key reservoirs. Australia's mixed approach involves states' rights over water allocation combined with a growing federal role in basin planning. Together, these considerations make Australia, Spain and the USA ideal countries for understanding and comparing the evolution and effectiveness of coordination institutions in water markets within federal countries.

## Materials

We use case-oriented methodology to construct and then compare the three countries across a set of focal institutional reforms (following Ross and Martinez-Santos, 2011). The empirical focus requires an analysis of: 1) trading activity within and across state and basin boundaries, 2) the distribution of authority, roles and responsibilities in water market reforms and 3) institutional responses to coordination challenges. We compiled available datasets on trading activity, examining the volume and types of transactions to characterize the trading patterns and contrast the coordination challenges associated with intrastate and interstate trading. We then conduct an institutional mapping of the distribution of authority and governance tasks between national and state levels based on documentary evidence (laws, policy statements and intergovernmental agreements), using a consistent list of governance tasks adapted from the Australian National Water Commission (2011, Table 1). Finally, process tracing techniques were used to examine the evolution of coordination institutions based on a constructed timeline. Collier (2011) describes process tracing as an analytical tool for making descriptive inferences within cases over time by tracing a 'temporal sequence of events' (pg 824). We

[1] Spain has 17 autonomous regions, which are hereafter called 'states' to ease comparison with the sub-national jurisdictions in Australia and the US.

used documentary evidence and secondary literature to identify critical junctures and patterns of trading activity, coordination challenges and institutional responses (based on Garrick 2015, Hernandez-Mora and Del Moral 2015 and summarised in Figure 2).

## Research setting: water allocation, markets and trading patterns

### Australia

Under the Australian constitution, the states have primary responsibility for water resource management within their borders, including the creation of water rights, the establishment of water trading rules, a water rights register and process for formal transfer of water rights, water accounting and reporting (Kildea and Williams, 2010, Williams and Webster, 2010).[2] In each state, the water rights include a permanent *water access entitlement* (the right to receive water each year) and temporary *water allocation* (the physical water available for use) (National Water Commission, 2013). Each state defines these rights slightly differently, and each state also created specific rules to manage interstate water trading. The current federal role in the water governance arrangements of the Murray-Darling Basin (MDB) stems from 2007, when the Millennium Drought caused the Australian government to commit $10 billion to improve the sustainability of the MDB, in return for state support of new federal legislation (Prime Minister of Australia, 2007). The Murray-Darling Basin is the most active region for water trading in Australia, comprising approximately 80% of national activity. The basin is shared between 5 states. Water trading has increased from approximately 1,000 GL/year (1,000 Mm3) in the Murray-Darling in 2007 to over 6,000 GL/year (6,000 Mm3) in 2016, with the majority of activity in the temporary market (Aither, 2016). Most temporary trade occurs within state borders, with total interstate trade of water allocation reaching a maximum of 33% (of total volume traded) in 2008-09 (National Water Commission 2014), confirming expectations in Figure 1 (below) that an absence of strong central coordination to overcome interstate conflicts makes interstate trading challenging. Permanent trade across state borders is subject to additional rules (Murray-Darling Basin Commission 2006), and no such trades have occurred from 2009-2016 (Bureau of Meteorology 2016). Water acquisitions for the environment by the federal government comprise one of the main drivers of permanent trading activity.

### Spain

Following the transition to democracy that started in 1975, Spain became a decentralized semi-federal country where 17 autonomous regions hold broad powers over most public policy issues. The law distinguishes between river basins that cross more than one autonomous region (interregional river basins) and those that fall entirely within a region. In interregional river basins, planning and management authority is held by nine River Basin Agencies (RBAs) that depend on the central Ministry with responsibility over environmental affairs. Water rights are historically held under different tenure regimes although successive legal reforms have favoured the public nature of these rights.

[2] See, for example, *Water Act 1989* (Vic), *Water Management Act 2000* (NSW), *Water Act 2000* (Qld), *Natural Resources Management Act 2004* (SA).

Water use rights are granted through renewable administrative concessions following the legal order of priority allocation established in river basin plans (Hernández-Mora et al., 2014). Water concessions are entitlements to annual volumes of water that can be used for a specific purpose in a specific location. Water trading mechanisms were introduced in Spain in 1999, although few transactions took place until the 2005-9 drought. Intrabasin permit trading has been the dominant form of formal trading in non-drought years, while public water banks and interbasin permit trading have been more prevalent during the drought, representing 53% and 40% of the total 445 $Mm^3$ traded between 2005 and 2009, respectively. 2008 was a peak year in terms of volumes traded (200 $Mm^3$). Like Australia, the vast majority are temporary trades (97%). Unlike Australia, where water trading comprises a substantial percentage of annual water allocations, trading activity in Spain represented less than 1% of all water used in 2007-2008, when trading was most active, but is more relevant (up to 4%) in highly stressed basins like the Jucar and Segura, where trading is prevalent (Palomo-Hierro et al., 2015).

## Western USA

State governments hold primary authority for water planning and allocation in the USA. Geographic differences have led to a divergence in the water rights systems between the Western US and the rest of the country. The 17 states with territory west of the 100$^{th}$ meridian have developed some version of the prior appropriation doctrine - a priority-based water rights system guided by common law (Tarlock 2002) whereby the first to establish and maintain a valid water diversion is the last to lose access in times of scarcity. The prior appropriation system has evolved from a highly decentralised system of individual claims to administrative permits regulated by each state and granted in perpetuity. The federal government's role in water allocation stems from its historical position financing and operating water infrastructure. The analysis will focus on the Western US and the states in three interstate and international river basins with water market activity - the Columbia, Colorado and Rio Grande Basins, which collectively illustrate the full spectrum of approaches to water market reforms and interstate coordination.

Over 4,000 transactions occurred in 12 Western states from 1987 to 2008 with buyers committing over $4.3 billion for leases and permanent acquisitions (Grafton et al. 2012). Trading activity is predominantly intra-state and temporary (via leases). Trading varies over time, with pulses of water trading during drought, in response to rapid urbanisation or for environmental acquisitions by the federal government. It varies geographically with Arizona, California, Idaho, Texas and Oregon among the more active states in terms of volume traded (WestWater 2016). Water trading also varies substantially within states. For example, transfers involving water storage projects administered by the federal government have become increasingly prevalent, including California (Central Valley Project and Lower Colorado Project), Nevada (Newland Project), Idaho (Snake River), and New Mexico (San Juan-Chama and Middle-Rio Grande) (US Bureau of Reclamation 2016). Inter-basin, inter-state transfers have been limited to the San Juan-Chama project involving the reallocation of water from the Colorado River to the Rio Grande, although the market transactions occur only between sectors after the water arrives in New Mexico. Inter-basin, intra-state transactions occur primarily in California and Colorado, the latter via the Colorado-Big Thompson, a federal project with approximately 140,000 acre-feet per year is traded in its seasonal rental market

from 2007-14. This comprises one of the more active markets, with 60% of the water available in those years traded through seasonal markets, as well as active permanent sales from 40-80 transfers per year often as a response to urban demands. Overall, the volume of water traded has been relatively stable, fluctuating between 1.5 to 2 million acre-feet per year (1,850 to 2,467 Mm3) from 2006 to 2016 except for 2010 when almost 2.5 million acre feet (3,084 Mm3) were traded.[3] The value of water traded ranges in response to volume and price considerations, spanning from $220 million in 2013 to almost $800 million in 2015 during the same 10-year period, according to WestWater LLC (WestWater 2016).

## Comparison of Trading Activity

The literature on water reallocation and markets suggests that political and institutional design challenges increase as transactions move water across sectors, political borders and/or basin boundaries (Hernández-Mora et al., 2013; Marston and Cai, 2016). While all water transactions pose a risk of conflict and coordination challenges due to third party effects (Colby 1990), the literature suggests that water trading over longer distances across sectoral, state and basin borders pose the greatest challenges and potential for third party impacts, as outlined in Figure 1, constraining expected trading activity even when there are large differences in economic productivity between basins and states. We expect inter-sectoral transactions to occur in all four quadrants, ranging from urbanisation of irrigation districts leading to water sales (intrastate, intrabasin) to interbasin trades, particularly within states (such as the North-South Pipeline transferring water from the Murray-Darling Basin to Melbourne within the state of Victoria).

[3] Time series data on Western US water markets are unavailable since the end of the Water Strategist newsletter circulated by the private firm, Stratecon, Inc until 2010.

| | INTRABASIN | INTERBASIN |
|---|---|---|
| **INTERSTATE** | Moderate Potential for Conflict<br>*Moderate Trading Activity*<br>*Australia*<br>17-33% of allocation trade<br>*Spain*<br>6% from 2001-16<br>*US*<br>Arizona-Nevada water banking | Highest Potential for Conflict<br>*Low Trading Activity*<br>*Australia*<br>limited to rural-urban transfers<br>*Spain*<br>37% from 2001-16<br>*US*<br>Not applicable |
| **INTRASTATE** | Lowest Potential for Conflict<br>*Highest Trading Activity*<br>***Australia***<br>**67-83% of allocation trade**<br>***Spain***<br>**45% from 2001-16**<br>***United States***<br>**Predominant type of water trading** | Moderate Potential for Conflict<br>*Moderate Trading Activity*<br>*Australia*<br>limited to rural-urban transfers<br>*Spain*<br>12% from 2001-16<br>*United States*<br>limited to inter-basin transfers within California and Colorado |

*Figure 1. Conflict Potential, Expected Trading Activity and Actual Trading Activity within and across States and Basins.* ***Bold*** *refers to most active* type of trading (volume traded *as a share of total volume traded across all types). In the case of Spain, trading activity in this quadrant corresponds mostly to public water banks and not to permit trading between permit holders. In all three countries, intra-basin and intra-state trading constitutes the plurality, and it is the majority in Australia and the US. However, the relatively high level of inter-basin, inter-state trading in Spain contradicts expectations. The central government plays an important role in facilitating interbasin trades due the high water productivity differentials between donor and recipient regions.*

# Comparative analysis

In the succeeding comparative analysis, we start with Spain (the most centralized example) before the USA (the most decentralized) and Australia (the mixed approach) to illustrate the similarities and contrasts.

## Distribution of authority and governance tasks in water market reforms

In this paper, we focus on *how* national and state governments are involved in the design of institutional reforms enabling, limiting or regulating water markets, specifically in terms of the balance of national and state government roles and the formal and informal institutional arrangements required (see Table 1). We compare the case studies in terms of a set of defined governance functions adapted from the Australian National Water Commission (2011).

***Spain*** represents the most centralized model of market-oriented reform. Until 1999 users could not exchange, sell or otherwise trade water rights without explicit intervention from basin authorities under exceptional circumstances, although some informal local water markets did exist in some areas (De Stefano & Hernández-Mora, 2016). In the context of a shifting discourse about water supply infrastructure development and in the aftermath of a major nationwide drought in the early 1990s, water markets were seen as an opportunity to introduce flexibility into the rigid concession system and avoid water use restrictions in urban areas surrounded by large irrigation districts. In 1999, two highly regulated water trading mechanisms were introduced: permit trading and public water banks. Water permit trading involves temporary agreements between water use concession holders in the same river basin, respecting the legal order of priority allocation, limiting trades to water effectively used in the past 3 years, and subject to approvals by river basin authorities (RBAs). Public water banks are set up and managed by RBAs. They operate under exceptional circumstances such as drought or groundwater overdraft and involve temporary or permanent purchases. Between 2005 and 2009 a series of exceptional annual drought decrees were approved by the central government to deal with a severe drought period. Among other measures, these decrees temporarily eliminated some of the restrictions to water trading included in the 1999 reform. Most significantly, the decrees allowed water trading between users in different river basins using existing interbasin transfer infrastructures. The reform aimed to compensate for drought-induced restrictions in the volumes transferred through the Tajo-Segura infrastructure, which transfers water from the Tajo River in central Spain to the Southeastern Segura river basin (Hernández-Mora & Del Moral, 2015). Water markets were most active during the drought period, both through public water banks and through permit trading between users in different river basins (Palomo-Hierro et al., 2015). Further legal reforms by the central government starting in 2013, permanently allowed interbasin trades and continued the market deregulation process in response to political pressures from Tajo-Segura transfer recipient regions and users (Hernández-Mora & Del Moral, 2015).

By contrast with Spain, the **Western USA** has a highly decentralised approach to water markets and related institutional reforms. The goals of water markets have included allocative efficiency and the delay or avoidance of new water supply infrastructure. However, the local control over water allocation under the prior appropriation doctrine has meant that the goals guiding the

development of water markets are highly localized, strongly conditioned by equity criteria and often only implicitly defined (rather than via an overarching policy at the state or national levels). The prior appropriation system and its decentralized approach to water allocation reform places a strong emphasis on irrigation organisations, which have considerable legal authority and political power within their borders, and political power through lobbying. Irrigation associations, companies and districts represent three distinct types of irrigation water supply institutions in the Western US. All three wield substantial control over water allocation within their boundaries, including the capacity to restrict water from exiting their jurisdiction (Bretsen and Hill 2006). Water transactions are therefore far more prevalent within than across irrigation organization boundaries (Ruml 2005).

At the state level, the prior appropriation system has involved administrative reforms and adjudications to close basins to new uses, reform water rights and establish trading rules with highly varied progress. An adjudication refers to the process of establishing the extent, validity and priority of water rights under the prior appropriation doctrine; the process involves a judge or an appointed special master reviewing evidence about historic water use and claims, often with substantial data and administrative support from water agencies. Colorado is at one end of the spectrum, where its state water court system and state engineer's office have established an advanced system of water rights administration with clear rules governing water transactions. At the other extreme, the Gila River and Yakima River water rights adjudications in Arizona and Washington, respectively, have been underway since the 1970s, creating legal uncertainty and constraints on some types of water transactions in both states (Feller 2008), although trading has been prevalent in selected management areas and irrigation districts. Even though the US is relatively decentralized, state water plans increasingly engage with trade and some legislatures have tried to enact regulations that would make trade a more available tool for water management by decreasing transaction costs, such as Texas and Oregon.

Despite its limited formal authority over water allocation matters, the federal government has affected the development of water markets through its management of federal reservoirs, where operational rules and contracts with irrigation districts stipulate criteria for water trading (Culp et al. 2014, Reclamation 2016). In 2016, the Department of Interior established the Natural Resources Investment Centre and conducted a thorough review of the federal government's powers and potential to promote water markets through its role managing federal reservoirs, its funding of water infrastructure and seed grants and its coordination of information relevant to water markets (Reclamation 2016).

The **Australian** reform process has followed a mixed approach, combining strong states' rights with an increasingly important federal role in basin-level planning and coordination of diversion limits, water rights systems and key information. Water rights in the MDB have been legally transferrable since the late 1980s, but the current mature water markets, in which large volumes of 'unbundled' water rights[4] are traded, did not emerge until 2007 (National Water Commission, 2014). Although the states initially led reforms in Australia, water transactions in the 1990s were highly limited, demonstrating the need for greater basin coordination among the states, and between the states and Commonwealth government. Despite progress, the states have not

[4] Unbundled water rights separate the permanent water access entitlement and the temporary water allocation from the land where the water is used; in fact, it is not necessary to use water on land at all.

made it easy to trade water across state boundaries. Victoria, for example, had a 4% cap on trading water outside a water district, which made trading interstate difficult. South Australia challenged this in the High Court on constitutional grounds; the case ultimately settled when the states negotiated a resolution to the dispute.

A range of reforms addressed these coordination challenges and embedded the water market in the context of national policy goals. Firstly, competition reforms in the early 1990s committed the Australian government to the use of market-based instruments to manage resources efficiently (Commonwealth of Australia, 1993). This led to the 1994 proposal of a 'cap and trade' water market for the MDB (COAG, 1994), and the Murray-Darling Basin cap was set in 1997 (Murray-Darling Basin Commission, 1995, Murray-Darling Basin Commission, 1998). In 2000, a review of a two-year pilot program for permanent interstate trade showed that cumbersome administration, inadequate water registers, and lax enforcement of water entitlements by the states were limiting the potential of the water markets to increase allocative efficiency (Young et al., 2000). In 2004, an inter-governmental agreement, the National Water Initiative (NWI) committed each state to the creation of transferable, secure rights to water, and support for water markets, in return for substantial financial incentives (COAG, 2004). The Australian government effectively 'purchased' state actions to improve water resource management in the MDB. However, even after the NWI, water trading was still relatively limited. In Victoria, annual permanent trade volumes hovered around 0.25GL (250,000 m3) from 1997-98 to 2005-06 (Department of Sustainability and Environment (Vic), 2008). In 2007, in response to severe drought and environmental degradation in the MDB, the Australian government passed the *Water Act 2007*, which created the Murray-Darling Basin Authority (MDBA). The MDBA is responsible for preparing the Murray-Darling Basin Plan (Murray-Darling Basin Authority, 2012). The Plan fundamentally affects the development of water markets by establishing a new, lower cap on water use (the sustainable diversion limit) which will apply from 2019, as well as establishing water planning processes and responsibilities at a broad level, including water trading rules (Hart, 2015).

Table 1. Governance Tasks and Institutional Reforms: National versus Sub-National Roles in Water Markets

| Governance Task or Reform | Australia | Spain | USA |
|---|---|---|---|
| **Rights definition and titling** | State | Basin Authority | State |
| **Water allocation** (annual determination) | State | Basin Authority | State |
| **Market and trading rules*** | *National* | National; Basin Authority | State |
| **Governance and planning,** (including diversion limits) | *National;* State | Basin Authority | State |
| **Market information*** (including supply, allocation and trade) | National; State | National; Basin Authority | State |
| **Compliance and enforcement** (including metering and monitoring) | National; State | Basin Authority | State |
| **Market administration and trade processing*** | State | National; Basin Authority | State |
| **Market intermediaries** | Private | Not required | Private |
| **Evaluation** | National; State | Not required | State |
| **Reporting** | National; State | Not required | State |

* *In Spain, market trading rules, information, and administration are carried out by the national ministry in inter-basin trades, and by basin authorities in intra-basin trades*

List of governance tasks adapted from: *National Water Commission, 2011. Strengthening Australia's water markets. Canberra. National Water Commission.*

## Coordination Challenges and Institutions

Australia, Spain and the USA have distinct approaches to water policy reforms resulting from their diverse institutional, political and historical contexts. These are reflected in the different goals of water markets and the varied roles central and sub-national governments play in the reforms discussed above. As a result they experience different types of coordination challenges, although interstate and interbasin trade has been a source of strain in all instances. In each case, coordination institutions and conflict resolution efforts have been used to address

intergovernmental and multi-level challenges with varying levels of success.

In ***Spain***, inter-basin and inter-state trading has been the source of disputes and coordination challenges between states and between states and the national government. As discussed above, water permit trading between river basins was allowed through the 2005-2009 drought decrees and permanently after a 2013 national policy reform (see Figure 2). Trading was most active during the 2005-8 drought, when over 70% of permit trading (excluding trades in public water bank) took place between users in different regions and over 90% between users in different basins. Autonomous regions (states) most directly affected by interbasin water trading have adopted different positions depending on their situation with regard to the Tajo-Segura water transfer: the main beneficiary states (Murcia and Valencia) supported water trading reforms in line with the position of the powerful water transfer irrigator association, SCRATS. The primary source state (Castilla-La Mancha) strongly opposed the liberalization of trading conditions. Social and environmental organizations have also opposed the sales and the government of Castilla-La Mancha has consistently (and so far unsuccessfully) challenged interbasin sale decisions in court. The 2014 and 2015 trading agreements between irrigators in the Tajo and Segura basins have also been challenged and are currently awaiting court ruling. Castilla-La Mancha sees interbasin sales as a mechanism to approve water transfers outside ordinary decision-making processes (where the regional government usually participates), damaging the interests of Tajo riparian towns and water users, and further deteriorating the environmental status of the Tajo River.

Although inter-state/inter-basin trade has been most conflict-ridden, not all intrastate trading activity has been exempt of conflict. In the case of the Segura river basin, trading agreements within the region of Murcia, southern Spain, where transfer recipients concentrate, have been contested by both traditional irrigator associations and social organizations (Calatrava & Martínez-Granados, 2015). In other cases, water markets have facilitated cooperation between states otherwise prone to conflict, particularly through the operation of public water banks. For instance, the Júcar basin public water bank that was operational during the 2005-2008 drought, reduced conflicts between two states (Castilla-La Mancha and Valencia) that have been embroiled in protracted legal battles over water allocation (De Stefano and Hernández-Mora, this issue).

In the ***Western USA***, water markets and associated institutional reforms have been shaped by three phases of inter-state and multi-level coordination challenges and institutional responses: interstate water apportionment, federal and tribal roles in water markets, and interstate 'water marketing arrangements'. In the first half of the 20th century, states sharing interstate rivers entered into 'compacts' to apportion water between themselves, creating bulk water allocations for each state within the basin. These interstate compacts, such as the 1922 Colorado River Compact and the 1938 Rio Grande compact, apportion water based on fixed volumes or proportional shares of the water available. Historically, the Supreme Court has been the primary venue for resolving inter-state disputes over compliance with the compact, illustrated vividly by the 40-year Supreme Court case on the Colorado River. In this context, water trading across state borders has historically been viewed with suspicion as a threat to the certainty achieved through hard-fought water sharing agreements. For example, a proposal for interstate trade in the Colorado River in the 1980s was critiqued as ''illegal, immoral, and dangerous to the current

comity among the states [that share the Colorado River]" (Kenney 2013). More recently, 'marketing arrangements' (ibid: 3) have developed in the Lower Colorado River as a means of introducing flexibility and risk sharing, building on the legal and institutional frameworks established by interstate compacts.

The role of the federal government in water markets has expanded, underscoring the importance of effective coordination between the federal and state governments, particularly associated with federal water storage projects. The US Bureau of Reclamation is a federal agency that operates 337 reservoirs with a total storage capacity of 245 million acre feet (302,203 Mm3), providing water for 10 million acres of irrigated agriculture supporting 60% of the country's vegetable production. Seven of the eight trading regions classified as 'high activity' by WestWater Research (2016) are located in regions with a federal water project and interstate water compact, demonstrating the need for both interstate and multi-level coordination institutions (US Bureau of Reclamation, 2016).[5] . Tribal nations are also emerging as an important influence on water trading in regions where their water rights are quantified. Vertical coordination between water users, states and state and federal governments has occurred through the planning and operation of federal water storage projects, adjudication processes, or statewide planning efforts where higher levels of governments participate on behalf of federal or tribal water rightsholders.

Water markets in ***Australia***'s Murray-Darling Basin are some of the most active in the world, and depend on cooperation and conflict resolution between the states and the federal government. River basin institutions have evolved over a century of intense political negotiations among the states and the Commonwealth government, marked by intergovernmental agreements for water market-oriented reforms since the 1992 Murray-Darling Basin Agreement (Connell 2007, Guest 2017). There are three primary coordination challenges: establishing a cap, ensuring compatible water plans and entitlement frameworks and recovering water for the environment. Inter-governmental coordination efforts have relied on the Council of Australian Governments and the Murray-Darling Basin Ministerial Council to facilitate negotiation and implementation of intergovernmental agreements as a key response to these challenges.

First, the 'cap' on water diversions has presented a persistent coordination challenge for states and the Commonwealth government (Heinmiller 2007). The 1995 recommendation to establish an interim cap required two years for final approval, and its implementation and revision have remained a chronic source of disputes, with states taking several years to comply (Queensland being the last, in 2010). The Commonwealth Water Act 2007 and its amendments established new federal authority and a mandate to establish sustainable diversion limits, and set trading rules, overcoming significant resistance and bargaining by the states (Kildea and Williams, 2011). Although no lawsuits have been filed, the states have demonstrated willingness to cut their funding contributions to joint water resource management programs (Bettles, 2013)(MDBA 2014).

[5] High market activity is noted by WestWater (2016) in the Central Valley of California, Southern California, Southern Nevada, Phoenix of Arizona, Northern Front Range of Colorado, Middle Rio Grande of New Mexico, Edwards Aquifer of Texas, and Lower Rio Grande (also Texas). All but the Edwards Aquifer are beneficiaries of federal water projects.

The second coordination challenge relates to ensuring compatibility of water planning and water access entitlement frameworks across states. One of the success stories of the water market in the MDB is its ability to transfer water between uses and locations quickly and relatively cheaply (Productivity Commission, 2010). Although the federal-state relationships remain a source of tension, water markets have provided an alternative to intergovernmental conflict over water. Renegotiating the distribution of water between the states would have been extremely difficult politically, but water markets have facilitated this redistribution to the highest value use of the water by supporting high volumes of allocation trade; during the Millennium drought, for example, a net export of 550 $Mm^3$ moved water from river valleys in New South Wales to Victoria and South Australia (Kirby et al. 2014). Like the USA, the final coordination challenge is associated with recovering and delivering water for the environment. Water markets have enabled significant and rapid water recovery for the environment, totalling a long-term average annual yield of approximately 1166 $Mm^3$ as of December 31$^{st}$ 2016. Despite initial support from irrigators (National Farmers' Federation, 2010), by 2015, irrigators were concerned that the Australian government department was acquiring too much water for the environment, and limiting the water available to irrigators. In response, the Australian government amended the *Water Act 2007* in 2015 to place a limit of 1500 $Mm^3$ on the total volume of water access entitlements that the Commonwealth Environmental Water Holder could acquire from the market (just over half of the total water recovery target of 2750 $Mm^3$ in the MDB).

| | | | pre 1980s | 1980s | early 1990s | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USA | | Responses | NL | OR | | | | | | | | | IGA | | IGA | | | | OR | | NL/F | | | | | | | F |
| | | Coordination Challenges | 1,2, 3 | 4 | | | | | | | | | 5 | | 6 | | | | 7 | | 8 | | | | | | | 9 |
| | Trading | Intrastate | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Interstate | | | | | | | | | | | Arizona-Nevada Water Banking | | | | | | Intentionally Created Surplus mechanism in Colorado River | | | | | | | | | |
| | | Inter-basin | Owens Valley | Colorado-Big Thompson project >>>> | | | | | | | | | | | | | Paloverde Irrigation District Leasing agreement (CA) | | | | | | | | | | | | |
| | | Drivers | | Droughts in California 1987-92; Rapid urbanisation | | | | | | | | | Droughts in the Colorado and Rio Grande, periodic droughts California and Northwest | | | | | | | | | | | | | | | | |
| Spain | | Responses | | | | | | | | | NL | | | | | | NDD | | | | | | | | NL | | NDD | NDD |
| | | Coordination Challenges | | | | | | | | | 1 | | | | | | 2,5 | > | > | > | > | | | | 3 | | 4,5 | 4,5 |
| | Trading | Intrastate | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Interstate | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Inter-basin | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Drivers | | | | | | | | | | | | | | | Drought | | | | | | | | | | Drought | |
| Australia | | Responses | | | IGA | IGA | IGA | | | IGA | | | | | | IGA, F | | | NL | IGA, F | | | | NL | | OR | | |
| | | Coordination Challenges | | | | 1 | 2 | | | 3 | | | | | | 4 | | | 5 | | | 6 | | 7 | | | | |
| | Trading | Intrastate | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Interstate | | | | | | | | Pilot Programme | | | | | | | | | | | | | | | | | | |
| | | Inter-basin | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Drivers | | | Algal blooms, Darling River | | | | Drought | | | | | | | | | | | Federal Acquisition of Water for the Environment | | | | | | | | |

*Figure 2(a): Trading Activity, Coordination Challenges and Institutional Responses. Shaded cells refer to the presence of drought and different types of trading activity, while selective text is used to describe other types of drivers (urbanisation and environmental recovery), key phases of trading and examples, which are indicative but not exhaustive. Numbers refer to key events identified in a timeline of coordination challenges (see legend below) in relation to a set of institutional responses, including intergovernmental agreements (IGA), funding (F), national laws (NL), national drought decrees (NDD) and operational rules (OR).*

| | | |
|---|---|---|
| | | **Legend**<br>**IGA** Inter-governmental Agreement<br>**F** Funding<br>**NL** National Law<br>**NDD** National Drought Decree (Spain)<br>**OR** Operational Rule |
| **Australia** | 1 | Growing water quality and drought impacts lead to Murray-Darling Basin Agreement (1992) and COAG water policy reform package (1994). |
| | 2 | Increasing competition for water leads to adoption of interim cap, followed by implementation lags and inter-state disputes . |
| | 3 | Demand for water reallocation between states leads to a pilot inter-state water trading programme, which experiences implementation barriers. |
| | 4 | Need to harmonise water rights systems across states leads to National Water initiative. |
| | 5 | Lags in drought response and environmental water recovery lead to National Water Act: diversion limits, water buyback and trading rules. |
| | 6 | Basin planning process identifies need for reduced water consumption causing intense political conflicts among states regarding diversion limits. |
| | 7 | Basin plan adopted in 2012, followed by new trading rules in 2014, requiring coordination between basin-wide and state planning efforts. |
| **Spain** | 1 | National water law established water markets in response to prior drought pressure. |
| | 2 | National drought decrees temporarily eliminates restrictions to interbasin permit trading agreements, leading to inter-state disputes. |
| | 3 | National law permanently eliminates interbasin permit trading restrictions. |
| | 4 | National drought decrees temporarily allow trading of the full concession, not only volumes effectively used. |
| | 5 | Legal challenges to interbasin water trading agreements between the Tajo and the Segura basins. |
| **USA** | 1 | Now defunct US National Water Commission identifies water transfers as 'water policy for the future' (1973), following a prior study in 1971. |
| | 2 | Growing water demands prompt water rights adjudications, which commence in the mid 1970s, encountering ongoing delays in selected states. |
| | 3 | US Congress passes legislation authorising water banking as a mechanism for storing and marketing water during drought. |
| | 4 | Interest in voluntary water transfers leads US Bureau of Reclamation to issue 'principles' guiding transfers of federally managed water supplies. |
| | 5 | Intergovernmental agreement between Arizona and Nevada for Arizona to store Colorado River water in aquifers to free up surface water for Nevada. |
| | 6 | Quantification Settlement Agreement in Colorado River forces water users to stay within water apportionments, creating de facto basin-wide cap. |
| | 7 | Drought triggers development of interim shortage guidelines for operating reservoirs in Colorado River, including interstate marketing agreements. |
| | 8 | Prolonged droughts and risks of water conflicts in the context of climate change lead to 2009 Secure Water Act. |
| | 9 | Severe droughts across Western US lead to creation of federal Natural Resources Investment Centre to stimulate development of water markets. |

*Figure 2(b). Legend: Coordination Challenges and Institutional Responses. NB: Can be moved to Supplementary Materials if needed.*

## Discussion

The comparative analysis demonstrates how water markets are affected by the federal system of water allocation and governance.

### How has the distribution of authority affected the goals of water markets?

Water markets have been associated with multiple policy goals in each of the case studies analysed, including allocating water efficiently, building resilience to drought, recovering water for the environment, sustaining agricultural communities, reducing the likelihood of or resolving conflicts, and creating flexibility in the water allocation system. Allocative efficiency is one of the primary goals of the water markets in all three countries. Intensified competition for water between irrigation, cities and the environment, and periodic droughts, have prompted reallocation efforts to maximise the economic value of water use. Beyond this fundamental similarity, the policy goals vary markedly across and within the three countries, and these differences are partially explained by variations in the (de)centralization of the federal system of water governance. These differences have important implications for defining success and assessing the performance of institutional reforms.

The policy goals guiding the development of water markets are not always clear, and this is a function of the level of centralisation in water planning and allocation decisions. Centralised development of water markets involves setting overarching policy goals and enacting the relevant legal and regulatory reforms to achieve these goals. Decentralised development of water markets involves the emergence of water trading in response to localized pressure and incremental institutional reforms. The centralised reforms in the Spanish case represent one end of the spectrum, with the main legal reform enacted by the central government in 1999. Motivated by drought experiences in the 1990s, the 1999 law introduced formal water market mechanisms as a means of 'enhancing efficiency or optimising the social utility of a scarce resource' (Casado-Perez 2015: 181). These were originally limited and highly regulated to overcome political resistance from irrigators, left-wing political parties and environmentalists that opposed the idea of treating water as a commodity (De Stefano, 2005; Del Moral et al., 2000, Casado-Pérez, 2015).

Water markets in the Western US are highly decentralised by comparison, involving a more ad hoc set of reforms and local 'emergence' of water trading, constrained by state-level regulations to limit negative third party impacts. By contrast with Spain, the policy goals are much more diverse as a reflection of the more decentralised approach to reform and the local values and interests involved. As a consequence, the goals attached to water markets are sometimes incompatible with one another, such as recovering water for the environment and sustaining agricultural communities (Reclamation 2016).

Australia's mixed approach, combining states' rights and increasing federal coordination, has led to a progressive shift in the policy goals from the interests of individual states to limit trading outside their borders, to national competition policy reforms promoting allocative efficiency at a basin-wide level in the Murray-Darling. Cap-and-trade regulatory reforms in Australia have involved a dynamic tension between these national commitments and state water resource

planning. Intergovernmental agreements have provided a key means of reconciling these goals, facilitated by the intergovernmental coordination institutions provided by the Council of Australian Governments and basin organisations.

In all three cases, the policy goals have evolved over time, through the changing balance of state and federal leadership in the institutional reform process and in response to changing political priorities and evolving power balances among different regions and interest groups. In the case of Australia, the boundaries of markets have narrowed and sharpened their focus on allocative efficiency even as the national government has used the market to address environmental water recovery objectives. In the USA, irrigation districts and states remain the dominant level for defining the goals of water markets and establishing boundaries or restrictions on their development in the public interest. The national government, and particularly the Department of Interior, has asserted itself in an increasing role using funding, information, studies and infrastructure modernisation and operations to promote 'water marketing strategies' for an expanding range of policy goals associated with water markets (Reclamation 2016). In the case of Spain successive national regulatory reforms, most recently in 2013, have eroded the original goals and restrictions on water trades that were designed to limit third party effects (Hernández-Mora and Del Moral, 2015). These reforms have so far had limited impact on market activity and have largely been enacted to satisfy specific interest groups, not to meet broader policy goals, such as improving allocative efficiency, achieving environmental gains or promoting the public interest.

## Institutional responses to coordination challenges associated with water markets

The three countries illustrate that water markets involve both intergovernmental (i.e. horizontal) and multi-level governance (i.e. vertical) coordination issues. Although a formal evaluation of intergovernmental coordination institutions is beyond the scope of this paper, we can identify and compare the types and quality of such institutional arrangements across the three countries to identify shared versus unique aspects.

Three coordination institutions have been relevant in all three countries, albeit in different forms and to different degrees: i) national or basin-wide coordination institutions (councils, basin organisations), ii) conflict resolution venues (particularly courts) and iii) venues for negotiating and implementing intergovernmental agreements (and their associated financing). In Australia and Spain, river basin authorities have played a fundamental role (see Figure 2). In Australia, the Murray-Darling Basin Commission and its successor, the Murray-Darling Basin Authority, have played an important coordination role in establishing and updating the cap, as well as the development of trading rules. In Spain, river basin authorities play a direct role in administering and approving trades associated with intra-basin public water banks and intra-basin trades, whether within a state or between states in the same basin. In the USA, interstate compacts and their implementing bodies, either the Bureau of Reclamation in the Colorado River or river basin compact commissions in most other interstate rivers, play a more indirect role, illustrated by the inclusion of water markets and related management options in basin-wide assessments

of supply and demand trends under basin studies program of the Secure Water Act. Interstate apportionment agreements also create a de facto cap on water supplies and an initial allocation of rights across states, which provides an enabling condition for water markets and has even led to experimentation with interstate water marketing arrangements.

Strong basin-wide institutions include mechanisms for dispute resolution, including conflicts related to water trading. Courts, or the threat of court action, have played a role in all three countries. In the USA, ongoing court cases have hindered the development of water markets in two ways. First, adjudications have struggled to quantify water rights, requiring decades in most instances with uneven success integrating federal and tribal reserved water rights. Second, interstate disputes have festered and created legal uncertainty, particularly disputes regarding the impacts of groundwater use on surface water deliveries (e.g. Texas v. New Mexico). In Spain, courts have been a venue for raising grievances associated with inter-state and inter-basin trades associated with inter-basin water transfers with limited success. In Australia, reliance on courts has been limited, but threats of High Court challenges have occurred and been used for bargaining by the states (Williams and Webster, 2010). The three cases illustrate the power of court action, but also show that over reliance on courts is a symptom of deficiencies in basin-wide coordination institutions.

All three countries have relied increasingly on the central government to provide political leadership, financial resources, and, in Australia and Spain, legal and regulatory reform. Australia's 2004 National Water Initiative, 2007 Commonwealth Water Act and 2012 statutory Basin Plan are the clearest example of this trend. In Spain, the central government has played a critical role in both initially regulating markets and then removing restrictions to water trades to achieve other policy goals or in response to pressures from specific interest groups (Hernández-Mora & Del Moral, 2015). In the US, the management and operations of federal water storage projects have created an important opening for national influence, which has grown with the Secure Water Act of 2009 and recent federal initiatives aimed at stimulating water marketing strategies as a solutions to drought.

Finally, the ongoing legitimacy of these coordination institutions associated with water markets in federal political systems depends on demonstrating accountability, and ensuring water trading and the institutional responses to associated coordination challenges are in line with the public interest. Australia's water market is noteworthy for its efforts to establish accountability mechanisms based on robust water market information. In Spain, the RBAs hold information on water rights and intra-basin trades, and the central government on interbasin trading, but reporting is not required and data is not easily or publicly available. In the USA, the situation is more complex. Information on water rights and transfers is available and reported in publicly available databases, and restrictions to avoid negative third party impacts are higher than the other two countries. However, the complexity of the water rights system and inconsistencies within and across states mean that existing information is inaccessible and insufficient to build legitimacy. Australia's experience suggests that the central government and basin-wide coordination institutions have a key role to play in establishing the data architecture and the reporting platforms to enhance transparency on trading patterns and their social, economic and environmental impacts. The lack of transparency in Spain and inter-state coordination of data and reporting in the US have exacerbated intergovernmental governance challenges.

## Conclusions

This paper has filled a gap in our understanding of water markets, illustrating the coordination challenges and institutional responses associated with the development of water markets in federal political systems. It focused on two characteristics of federal systems of water governance that affect the goals, design and evolution of water markets: the distribution of powers and functions in water allocation and the intergovernmental coordination challenges and institutional responses associated with water markets. The diverse experiences of the three countries demonstrate coordination institutions must be well-developed for water markets to achieve their goals. Accountability mechanisms are essential for the legitimacy of water markets, ensuring accessible information about trading activity and impacts of trading activity on other local and national policy objectives related to equitable water allocation.

The three cases illustrate that context matters, specifically the level of centralization and the goals of the water market. Despite contrasting institutional arrangements and policy goals, however, the comparison offers clear lessons about the importance of regional politics and coordination institutions for effective and equitable water markets in federal political systems regardless of the level of centralization. For water markets to achieve their intended goals and limit unintended or negative consequences, they must be developed within a framework of strong coordination institutions and buttressed by robust and transparent information systems, particularly when water is traded long distances and across jurisdictional or basin borders. This finding rebuts the conventional wisdom and initial logic of market-based environmental policy, which is premised on the perceived failure of regulation and promise of private property and decentralisation. Effective governance and markets go hand in hand.

Future research should consider the impact of water markets and associated institutional reforms on the broader goals of the federation, such as representing diverse interests, enhancing legitimacy and ensuring accountability. Further comparative institutional analysis of water markets can shed light on the relationship between federalism and water markets by: (i) identifying principles, such as the subsidiarity principle, to guide the assignment and division of powers and functions in different institutional contexts , (ii) developing in-depth studies of water markets and their structure and perfomrnace using common concepts and frameworks to aid comparison, and (iii) constructing and apply common metrics for evaluation across cases and over time. In so doing, it can inform the development and implementation of context-sensitive pathways of institutional development.

## Units

SI = 1 Mm3 = 1,000,000 m3
**Australia**: GL = gigalitre, 1,000,000,000 litres or 1 Mm3 = 1,000,000 m3
**Spain**: Mm3 = 1,000,000 m3
**USA**: acre-foot = the amount of water to cover 1 acre up to 1 foot in depth = 1233m3

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