Cap-and-trade of Water Rights

A Sustainable Way out of Australia's Rural Water Problems?

In regions with uncertain water availability it is extremely difficult to balance water supply between farmers and ecosystems. A promising solution seems to be a cap-and-trade scheme, which defines extraction limits while water rights can be traded to ensure an efficient water allocation. As the Australian case shows, if caps are not tight enough and markets too restricted by trading rules and barriers, a sustainable water use is hard to achieve.

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Abstract

Trading water rights is a tool for re-allocation of water resources in water-scarce regions such as Australia. Tradable water rights help farmers to act flexibly when facing high fluctuations in water availability and to use the water in a sustainable and environmentally friendly manner. A precondition is that the quantity of water rights is capped at an appropriate level. The institutional arrangements and market structures in which water-right trading is embedded are key factors for the success of such water management instruments. By analysing the structure of the water-right market and water caps as well as using results from explorative expert interviews, the article sheds light on potential problems with the Australian cap-and-trade scheme concerning sustainable water usage. It also asks whether the Australian scheme provides lessons to be learnt by other countries facing similar problems.

Keywords

Australia, cap-and-trade schemes, rural water management, sustainability, water policy, water-right trading

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The Necessity for a Solution in Times of Water Scarcity in Australia

Australia is one of the most vulnerable countries in the world in terms of severe droughts and water scarcity. This leads to the particularity of Australia's water supply which is affected by high variability of water availability. Severe extended droughts are followed by massive floods within a single decade, as seen from 2001 to 2010. Consequently, planning the distribution of water is subject to uncertainties since the accurate prediction of water supply is impossible. Therefore, it is important that restrictions on water use (caps) are combined with flexible water markets to be capable of responding to fluctuating water availability.

More Irrigated Agriculture, Increased Water Consumption

In Australia, water scarcity is an effect of droughts. However, water scarcity has become more intense due to a rise in water consumption over the last 50 years, mainly as a result of increased agricultural production and an expansion of irrigated agricultural land. Agriculture is the sector with the highest water consumption. In the water year 2004–05, it accounted for 12,191 gigalitres or 65 percent of total water consumption (ABS 2006) and in 2008–09, despite the long-lasting drought, still for more than half of the water use (7,589 gigalitres) (ABS 2010). From 1990 to 2012, production of water-intensive crops has grown, for example, by 16 percent (rice), 155 percent (cotton), and 95 percent (grapes) (ABARES 2013).

Despite unfavourable climatic conditions for irrigated agricultural production, large quantities of crops were exported. For instance, from 1968–69 to 2012–13 a yearly average of 74 percent of Australia's rice production was shipped abroad (ABARES 2013). In 2011, Australia was the world's third largest cotton lint exporter and fourth largest exporter of wine.[1] Irrigation of those crops accounted for more than half of total agricultural water use in

1 FAOSTAT: http://faostat.fao.org/site/342/default.aspx.

http://dx.doi.org/10.14512/gaia.23.4.7

2011–12 (ABS 2013) in the Murray-Darling Basin. Situated in the South-East of the continent, the Basin is one of the largest river systems in the world and Australia's most fertile region. It contains 65 percent of Australia's irrigated land area, and connects four Australian states – Queensland, Victoria, South Australia, New South Wales – and the Australian Capital Territory.

Historically, water was a good free of charge in Australia and the rights to use surface water were bound to real estate (so-called riparian water rights). In the beginning, this worked well because the initial irrigators were located close to the rivers. Around 1915, the Australian Commonwealth government[2] started to create smallholdings producing horticultural crops (especially in the southern Murray-Darling Basin) and offered them to people who had immigrated to Australia after the First World War. Additionally, many soldiers returning from war were out of work. They purchased these blocks to start agricultural businesses, as expert interviews revealed. As the number of irrigating farmers increased, more riparian water rights were issued by the state governments.

Each state government provided water rights for users of their own district without acknowledging the complex character of river morphology and hydrologic processes in a river basin as a whole. Especially during drought periods, the management of water without considering water rights granted by neighbouring states in the same basin resulted in tremendous over-allocation and created unhealthy conditions in rivers, wetlands, and floodplains. This was especially observed in the Murray-Darling Basin.

From 1994 until 2001 the average annual flow of the River Murray showed fluctuations due to recurring droughts and floods, but also had an overall decline. Figure 1 illustrates that the high intensity of irrigated crop production has not been affected by changing water availability levels of the River Murray.

In order to manage a situation where a common resource of scarce water has to be shared by different states and territories with different regulatory responsibilities, there was a need to coordinate water allocation. In order to establish sustainable water management and protect ecosystems, different water reforms have taken place in Australia since 1994, including restrictions on water extractions and trading of water rights.

Cap-and-trade of Water Rights

Key Characteristics of Australian Water Management

The current Australian water sector consists of many single water markets, where each is defined by administrative boundaries and bodies of water such as river flows (NWC 2009). On each market, rights are defined to extract water for a particular period of time, at a particular location. 82 percent of available water rights are for withdrawing surface water, and 18 percent of total national water rights are related to groundwater (NWC 2010b). Groundwater extraction and trade of seasonal groundwater allocation rights become especially pivotal during droughts when surface water is scarce.

Australian water rights are differentiated between *water access entitlements* and *water allocations*. The definition and main differences between these two types of water rights are explained in table 1 (p. 320).

The system of water rights can be compared to managing real estate. Owning a house is equivalent to water access entitlement, while renting it out for a fixed period of time corresponds to wa- >

2 "One must differentiate between the Australian government, which is the Commonwealth, and the Australian states and territories (which are Queensland, the Northern Territory, Victoria, South Australia, Western Australia, New South Wales, the Australian Capital Territory, and Tasmania). Hence, both, state governments and the Australian Commonwealth government intervene in water markets" (Burdack 2014, p. 21).

FIGURE 1: Australia's irrigated agricultural area and average annual flow of the River Murray, Australia's second longest river, 1994–2012. Changing water availability levels of the River Murray, which flows through one of the most productive agricultural regions of Australia, have not affected irrigated crop production. Source: Data from DEPI (2013) and ABS (1994–2012).

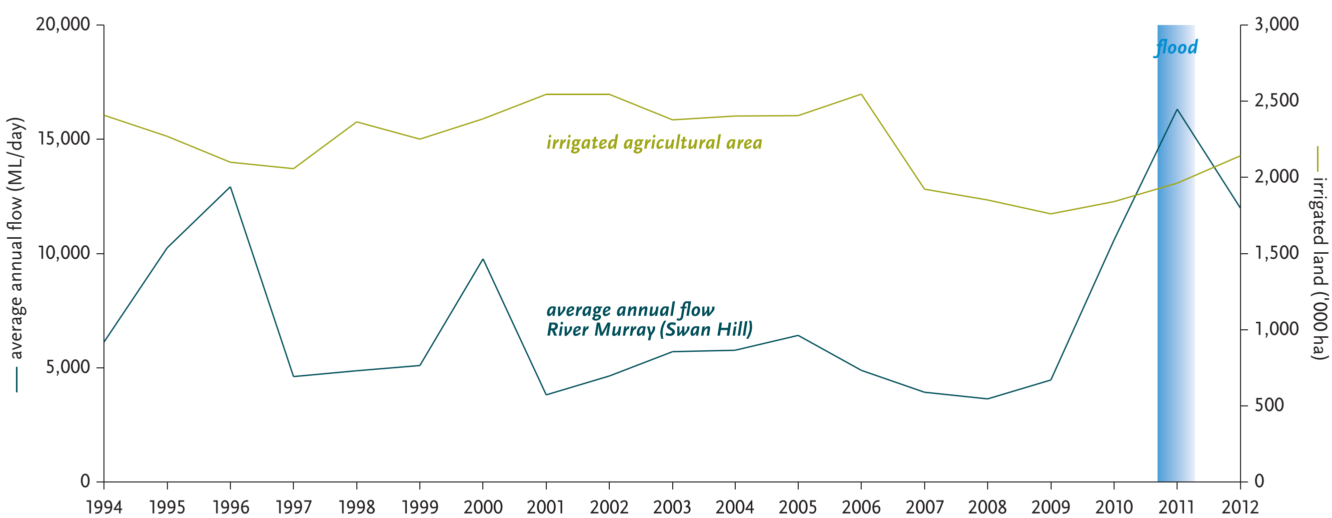


TABLE 1: Differences between water access entitlements and water allocations.

	water access entitlements	water allocations
definition	permanent rights to exclusive access to a fraction of water from a specified consumptive pool as defined in a water plan (NWC 2010b)	seasonal rights specifying a volume of water allocated to water access entitlements relative to the overall available volume (NWC 2010b)
particularities	Within this pooling arrangement, every water access entitlement holder of the same kind of entitlement has the same status, and allocations are made in proportion to the number of water access entitlements held (Young 2010) as well as depending on the reliability class of the entitlement. *High-reliability* water access entitlements usually have a 95 to 100 percent chance of being allocated with water. *General-reliability* water access entitlements have lower reliabilities and are only allocated after high-security water access entitlements have been met completely (Shi 2006, Peterson et al. 2004, Grafton et al. 2009).	These withdrawal rights are seasonal caps announced by state governments[a] for a specific water resource from water storages (such as dams) or rivers. They depend on the available volume of water from water bodies and rainfall events (ACIL Tasman 2004). Irrigators and other rural water users must own water access entitlements to be able to receive water allocations. Their allowed water consumption is limited to the restricted volume of water allocations that are announced seasonally. Total water allocation must not exceed the maximum volume defined in accordance to water sharing plans (regional caps) that are fixed for a long period of time (about ten years).

a The timing of state-governmental announcements differs across regions. For instance, in the jurisdiction of the water provider Murrumbidgee Irrigation, the state government announces allocation caps on the 1st and 15th of each month (personal communication with Brad Power 2011).

ter allocation trade. An owner can sell his or her house only once, but can again dispose of it freely after the rental period.

In addition to these water rights, quantitative limits for water extractions are defined in the Murray-Darling Basin for specific water bodies. These caps are hierarchically structured.

Overall cap: An overall basin-wide cap sets quantitative limits for water usage from ground and surface water resources to provide for a sustainable water allocation in the Basin. The first overall cap was introduced by the Council of Australian Government's agreement in 1994. It defined a rural extraction limit of 11,500 gigalitres per year (Khan et al. 2009). However, this maximum volume of extractable water turned out to be too high in times of drought. The Murray-Darling Basin Authority, established in 2009 as statutory agency responsible for overseeing the sustainable water resources management in the Basin, therefore reduced the cap to annually 10,873 gigalitres for surface water until 2021 in the highly debated *Basin Plan*.[3] This reduction might still not be sufficient since research suggests that about 4,000 gigalitres of water per year need to be returned to the Murray-Darling system to provide sufficient flow and keep water-dependent ecosystems healthy along the rivers (Young 2012). However, the volume of 4,000 gigalitres per year does not take seasonal fluctuations and weather conditions into account.

Regional cap: State governments then have to decide individually how they specify water sharing plans for each single region within the state to achieve the Authority's goals formulated in the *Basin Plan*.

Seasonal caps: During the season state governments frequently announce how much water can be allocated to the owners of water access entitlements.

In 2010, about 190 regional caps existed, each following diverse approaches to solve conflicts between competing water users including the environment (McKay 2011). The goals of these caps are diverse. Some aim to protect ecosystems and water bodies, others manage water use and water sharing divisions (Hamstead et al. 2008).

When the long-term drought had its peak in 2007–08 (figure 2), even high-reliability entitlement holders were affected quite severely, as expert interviews confirmed. By applying seasonal caps that were adjusted to the circumstances of drought, only between 30 and 55 percent of the potential volume were allowed to be delivered to high-reliability water access entitlements in New South Wales, Victoria and South Australia. General-reliability water access entitlements were not allocated for most of 2007 (NWC 2008).

When announcing seasonal caps, state governments face tremendous trade-offs. On the one hand, the caps must be stringent enough to protect the environment from excessive consumption in advance. The difficulty is that sustainable extraction levels cannot be determined with certainty since weather extremes are not predictable and water availability faces a high range of variability. On the other hand, caps that are too tight (and therefore available water for farmers too little) may be economically challenging if farmers lose their harvests due to missing irrigation opportunities.

To achieve sustainable extraction levels, even if a drought is especially severe or after "sleeper entitlements" (see below for explanation) were activated, the Australian Commonwealth government buys back water access entitlements and redefines the overall cap. The overall cap, regulating the supply, is combined with water markets. Trading water rights leads to proper price signals and ensures an efficient water allocation.

The Australian Water-right Trading Market

Trading of water rights in Australia may occur within or between regions (Young 2010). Water-right trading was established in 1994 by the Council of Australian Government's agreement. This sep-

3 *Basin Plan:* www.mdba.gov.au/what-we-do/basin-plan.

arated water rights from the land and enabled water-right trading within one irrigation system.[4] In the course of time, trading rules permitted trade between connected irrigation systems within one state (MDBC 2008). In 2004, the *National Water Initiative* took water-right trading one step further: the Australian territories/states and the Commonwealth agreed to an expansion of water markets across regional boundaries and state borders (the so-called interstate trade) (NWC 2010b). Under this initiative, water-right trading is possible within the Basin, which can be seen as an expansion of the water market with the advantage that monopolistic structures (regarding services such as water metering and water deliveries) are weakened.

Recommendations on water-right trading rules are provided by the Australian Competition and Consumer Commission as an independent Commonwealth statutory authority (Commonwealth 2011). The Murray-Darling Basin Authority intends to integrate these recommendations in the *Basin Plan* that commenced in 2012 (NWC 2011). The Authority detects risks to a sustainable level of water resources and establishes basin-wide trading rules (NWC 2009). Basin-state-trading rules are still existent but need to be consistent with the Authority's rules (MDBA 2013).

When the scheme for water-right trading was established in 1994, most of these rights were not activated[5] and were therefore called "sleeper entitlements". After most of the sleeper entitlements were offered on the water market, trade between agricultural producers increased, with water low value users[6] such as rice farmers selling their water rights to water high value users such as grape famers to gain higher profits (ACIL Tasman 2003, Tisdell et al. 2002). In principle, trade enables the achievement of the optimal allocation of water to the most profitable uses. However, the activation of sleeper entitlements led to an increase of water consumption and resulted in more severe environmental problems particularily during droughts.

FIGURE 2: Since water managment was not sufficiently adjusted to seasonal conditions and the river morphology and hydrologic processes, the last drought (2001–2009) in the Murray-Darling Basin resulted in severe damages.

Water access entitlements and water allocations can be traded between sellers and buyers by using the internet without time delay. Water plans, trading rules, and legislation constitute the framework for trading water rights. Intermediaries in Australia's water markets, who can be lawyers, water exchangers, or water brokers, facilitate the trade. They provide transactions and information services. The activities of intermediaries are unregulated with the consequence that no barriers exist for someone to enter the market as an intermediary (NWC 2009).

In the Northern Territory, Western Australia, and Victoria, participation on the water-trading market is only possible for those who own land and are able to demonstrate a use for water (NWC 2010a); this policy is intended to prevent speculation. In other states, non-landholders and speculators are able to buy and sell water rights by participating in the market. However, cases of speculation that have a serious impact on farmers are not yet known according to experts (personal communication). Water access entitlement trading until now primarily involves surface water rights rather than groundwater rights (NWC 2010a).

Trading Rules, Barriers and Difficulties

Trading water access entitlements encounters many barriers. For inter-state trade a method called "tagging" is used that tags the water access "entitlement in its state of origin for use in the state of destination. The entitlement retains its source characteristics and allocations, but water is extracted in the state of destination" (NWC 2010a). A volumetric limit for tradable water access entitlements is often imposed on inter-state trade. In New South Wales and Victoria, for example, only four percent of the total volume of traded water access entitlements may be exported out of an irrigation region annually. Once this limit is reached, trade from this region will be rejected until the end of the water year. In 2007–08, the Victorian "four percent limit" was estimated to cause a welfare loss of 1.5 million Australian dollars (AUD) due to the denial of a volume of 7.3 gigalitres of water access entitlement trade (Frontier Economics 2009). Thus, the "four percent limit" ultimately prevents resource efficiency. These problems and trade >

4 The irrigation system "consists of a (main) intake structure or (main) pumping station, a conveyance system, a distribution system, a field application system, and a drainage system" (Brouwer et al. 1985).
5 This means that farmers left a part of their water rights unused.
6 The authors derive the definition for water low value users from the proportion of Gross Value of Irrigated Agricultural Production (GVIAP) to quantity of used water for production, which is below 1,500 AUD per megalitre. GVIAP is defined by the Australian Bureau of Statistics as "the gross value of agricultural commodities that are produced with the assistance of irrigation" (ABS 2010). Consequently, water high value users' water productivity is above 1,500 AUD per megalitre.

TABLE 2: Average price for traded water access entitlements and water allocations. Source: NWC (2010 a, 2013 a).

water year	2007–08	2008–09	2009–10	2010–11	2011–12
high-reliability water access entitlement rights (AUD/ML)	1,750	~ 2,000	2,100	1,900	1,750
general-reliability water access entitlement rights (AUD/ML)	na	~ 1,000	1,250	1,010	1,030
water allocation rights (AUD/ML)	650	350	150	32	17

restrictions could be avoided, if overall caps were sufficiently low and designed in view of the water withdrawals of neighbouring states.

In addition to the "four percent limit", in Victoria for example, trade is only permitted if the net effect of trade is zero. In most cases it will not be possible to trade downstream if the equivalent amount was not previously traded upstream. This bottleneck system (MDBC 2006) is supposed to prevent that too much water is available in an upstream region and that consequential trade causes environmental problems in a downstream region. Although the bottleneck system is very valuable from an ecological point of view, it might limit efficiency-improving re-allocation mechanisms, which then also hinders a long-term equilibrium on the water market (Shi 2006, Brooks and Harris 2008).

Furthermore, when water access entitlements are sold to a water user outside an irrigation district, bulk water providers and irrigation infrastructure operators[7] charge an exit fee of 870 AUD per megalitre maximum depending on infrastructural operators and the reliability class of traded water access entitlements. Some exit fees are as high as 80 percent of the value of the traded water access entitlements. This might be one reason why inter-state trade is relatively rare (ACCC 2006).

Since the cap is not always perfect, water-right trading has negative side effects. Khan et al. (2009, p. 493) discuss the "nexus between water (right) trading and groundwater-induced soil salinity in (...) the Murray-Darling Basin". When water rights are traded out of an area that is particularly vulnerable to salinity, the irrigation water is missing and unable to rinse out the salt from the soil when the water table is shallow (Khan et al. 2009).

Water access entitlements and water allocation rights can be traded between entities such as irrigators, other rural water users, water infrastructure operators (authorities), and environmental water managers (IPART 2010). Next to these market participants, the Australian Commonwealth government buys water access entitlements as part of the *Water for the Future* programme that comprises strategies to prevent over-allocation of water and giving it back to the environment (NWC 2008). The double role of the Australian Commonwealth government could be problematic in terms of neutrality and impartiality since the government interferes by setting trading rules and water plans, but at the same time participates actively in the market.

The above examples show that there are many barriers and difficulties which could hinder the cap-and-trade system in meeting the goal of allocating water rights efficiently: while some of them are justified (like the bottleneck system), many others are not. Barriers to a free and working market are the lack of uniformity in terms of water-right labelling,[8] trading rules, and a lack of cooperation between states and water districts in the Murray-Darling Basin. This means that the transparency of the water market is limited and transaction costs are high, which can lead to the exclusion of farmers and other water users. A lack of transparency also exists because "there are no consolidated and consistent water-trade records for the Basin" (Jiang 2011, p. 282).

Temporary and Regional Differences

Trading transactions occur mostly in the Australian summer between October and March, when water is rather scarce in Eastern and Southern Australia. In peak times, hundreds of water allocation trades may be handled within only a few days (NWC 2008).

The intensity of trading activities varies widely between different regions of Australia. A concentration of transactions can be found in the Murray-Darling Basin: here more than 94 percent of the total trading volume of water rights in Australia are transferred (NWC 2013 b). But also within the Murray-Darling Basin regional differences exist, as most transactions (81 percent of the Basin's total volume of traded water rights) occur in the southern part (NWC 2013 b and information from interviews).

Regional differences in trading activities are caused by trading barriers and differences in surface and groundwater resources. Most permanent entitlement trading activities occur within states. One of the reasons for the moderate inter-state trading activity could be the above-mentioned exit fee that is charged for transactions outside of an irrigation district. In contrast, no exit fees apply for seasonal water allocation trade. This freedom from charges is reflected in an active inter-state water allocation trading market. Most inter-state water allocation trade is downstream (NWC 2009, 2010 a).

Price Differences

The total value of turnover of water access entitlements for Australia as a whole was approximately 1.5 billion AUD and total sales

7 Bulk water operators harvest, store, and transport water to their customers who are farmers or irrigation infrastructure operators. Irrigation infrastructure operators connect their customers to water bodies by a network, which may be comprised of pipes, open channels as well as pumps if no gravity can be used for water transportation (SunWater Limited 2012).

8 For example, in South Australia high-reliability entitlements are called *water holding licenses*, and in Victoria *water rights*. General-reliability entitlements are called *water taking licenses* in South Australia and *diversion licenses* in Victoria (Shi 2006).

of water allocations amounted to 78 million AUD in 2011–12 (NWC 2013a).

Prices for traded water rights depend on their type, trading regions, reliability classes, and time of the trade.

As illustrated in table 2, the average price for high-reliability water access entitlements was almost twice as high as for general-reliability entitlements. Price differences are highest in regions that are not connected to other regions (e.g., via a river) (NWC 2010a). The average price for high-reliability water access entitlements increased by 20 percent from 2007–08 to 2009–10 (to 2,100 AUD per megalitre), but fell back to the initial price level of 1,750 AUD per megalitre in 2011–12.

The identical average price for high-reliability entitlements in 2007–08 (which was a very dry year with a traded volume of 770 gigalitres) and in 2011–12 (which was a wet year with a traded volume of 1,219 gigalitres) shows that the price of traded water access entitlements does not reflect seasonal fluctuations of water availability or the volume of traded water access entitlements. This might be explained by expectations of water users about the next drought and the Australian Commonwealth government's intervention on the trading market in the context of the *Water for the Future* programme.

In contrast, prices of water allocation rights peaked in 2007–08 when the drought was most severe. With increasing precipitation and alleviation of the drought, the price for water allocation rights decreased by more than 97 percent by 2011–12 while the volume of traded water allocation rights increased by more than 200 percent. This indicates that many water-right holders sold their water allocation rights as a result of water abundance. With increasing volume, market prices of water allocation rights decreased. Hence, the market price of water allocation rights does reflect water availability which can be seen as an indicator for a functioning market.

Effects of Water-right Trading

From Low to Higher Value Water Use

Trading water rights provides water users with incentives to improve their water use efficiency and to save water, and it enables farmers to sell any unused water. With this opportunity, no "use it or lose it" strategy needs to be pursued as happens in other countries (Grafton et al. 2009). Trading water rights helps to gain allocative efficiency by providing the highest value user with water.

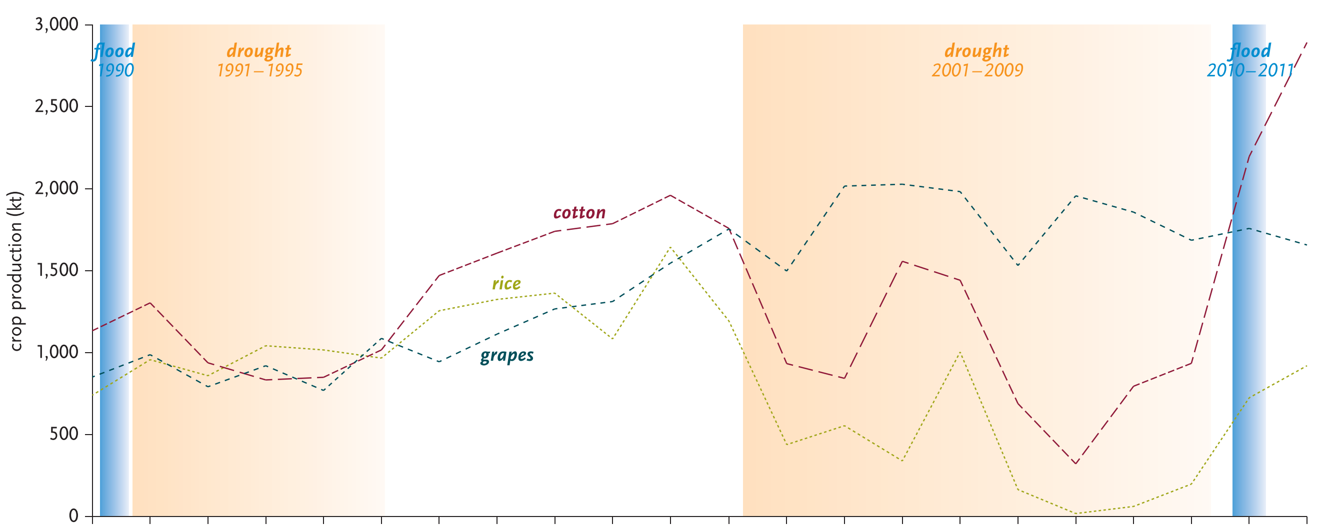
The price for seasonal water allocations provides information about seasonal water availability and demand on the water market. High prices for water during dry years are a huge incentive for farmers who cultivate irrigation-intensive annual crops[9] to sell water rights and generate profits since the profits from water-right trading could be actually higher than the profits gained by cultivating irrigation-intensive crops during a drought.

Farmers with water-low-value annual crops sell water rights to those who cultivate water-high-value perennial crops (personal communication). If farmers of perennial crops were not able to increase their water inventories as a response to weather conditions, they would lose entire harvests. For example, grape farmers bought water from rice farmers and paid high prices for the additional water to keep their plants alive.

As a result, irrigation-intensive water-low-value annual crops are usually not cultivated when the market price for water is high (as shown in figure 3), and water rights are traded to water users with higher value crops. Water trade enables water users to better adapt to seasonal weather conditions. It helps to gain some profit for farmers selling water and to bridge water shortages and precipitation variability for farmers buying water during dry years. >

9 Such as rice and cotton.

FIGURE 3: Crop production. In times of drought, water users with water low value crops (like rice) tend to sell water rights to water users with water higher value crops (like grapes). Hence, trading water rights enables farmers to better deal with seasonal water availability and improves their water use efficiency. Source: ABARES (2013).



Ecological Consequences

The inappropriate combination of regional caps and the water-right trading scheme before 2012 has led to a serious over-exploitation of many water bodies in the Murray-Darling Basin, and recovering the ecological balance does take time. It is too early to say if the *Basin Plan* can fix the water-accounting problems.

Lessons Learnt[10]

The cap-and-trade-system promises to be a solution to rural water problems in Australia, as long as the cap is tight enough and the flexibility of the market is not restricted by too many trading rules and barriers. The current system still needs improvement but lessons can be learnt from the past experiences.

1 ***Trade can counteract sustainability, if the overall cap is not tight enough.*** When originally unused water rights (sleeper entitlements) are traded, then the volume of the actual consumed water increases. The additional usage of water may result in environmental damage. Therefore, the Australian Commonwealth government has been buying back water access entitlements in order to achieve sustainable water allocation schemes since 2007–08.

2 ***Trading barriers impede free water-right trading.*** In Australia, water-access-entitlement trading activities so far have been modest. High exit fees and the previously explained "four percent limit" have constrained trade so strongly that there was nearly no inter-state entitlement trading during the past few years. Barriers might be reasonable in aiming to prevent over-exploitation in some regions as long as caps do not include basin-wide water extractions. But they also limit the application of a well-functioning trading scheme. Hence, a balance between state intervention and free markets must be found. From an economic point of view, state interventions are only meaningful in cases of market failures and when the initial situation has to be improved.

3 ***A uniform and clear system is essential.*** It is a big disadvantage that the same kinds of water rights have different labels and categorisations in different Australian states and territories. This makes it hard to obtain an overview of trading possibilities and increases transaction costs resulting from information acquisition for both buyers and sellers. Additionally, market information should be accurate, complete, timely, and unambiguous. The possibility to trade via the internet enables higher transparency and improves the comparison of market prices.

4 ***The coordination of water extraction from cross-border water bodies is crucial.*** In order to prevent unsustainable water management due to the lack of coordination between Basin states, the independent and inter-state governmental Murray-Darling Basin Authority was established in 2009. All states with territory in the basin conferred their water-planning powers to the Murray-Darling Basin Authority (NWC 2009). Through establishment of this inter-state institution, not only water planning, rule setting, coordination, and control of water markets, but also the achievement of objectives such as sustainable water management and healthy environmental conditions can be pursued for the whole river basin.

5 ***Trading requires skills and training.*** Trading water rights is a very complex process in which farmers have to take decisions which go beyond farming. Australian farmers not only have to decide which kind of crop they want to cultivate, but also when they want to buy, keep, or sell water rights. Farmers (especially with general-reliability entitlement classes) cannot be sure how much water they will actually get and whether this amount of water will be enough throughout the cultivation season without paying a very high price for water rights when water becomes scarce. Taking the right decisions is challenging. This pressure and the financial situation of farmers were so serious during the last long-term drought that the state government decided to supply desperate farmers in severely affected regions with mental-health workers to prevent suicides (Kumagai 2010). Hence, farmers need training and support to develop a wide range of skills and competences, as well as strategic foresight, to be able to participate successfully in water-right trading.

6 ***Short-term responses are possible.*** Water users are better able to respond to unpredictable droughts through the opportunity to buy or sell water rights. Especially during droughts, less water-efficient farmers cultivating low value crops are able to sell their water rights to high value crop farmers who need to irrigate perennials such as grapevines or fruit trees. At the same time, water trade provides the possibility to gain some additional income. This flexibility is a chance for farmers to "survive" seasonal water variability, which could become even more severe if climate change leads to longer water shortages and more weather variability.

These are the lessons learnt from the Australian water-right trading experiences. It shows how complex the development of a well-functioning water-right trading market is and what challenges could occur if this concept is going to be applied to other regions in the world.

Applicability to Other Regions

Australia and other regions in the world face extreme weather conditions and huge water variability that makes it difficult for farmers to maintain a constant level of crop production. Despite this challenge, Australia is a big producer and exporter of agricultural products.

These circumstances are similar to other countries such as South Africa. This does not mean that water-right trading is equally applicable in those countries. Since Australia has a stable polit-

10 Results from research study of Burdack (2014).

ical system with sound institutions, good education, and a good financial situation, investments in high technology and research help to mitigate the above-mentioned disadvantages. Additionally, water rights and water-right trading can only fulfil their intended function when systems are stable and users can trust in their persistency, since this is the basic condition for developing and investing in long-lasting water conserving systems (Solanes 2001).

During drought periods, the price for seasonal water rights increased and many Australian farmers were in serious financial difficulties. But state-governmental initiatives supported farmers affected by losses and financial pressure. In countries without comparable support schemes, for example, in parts of Africa, especially subsistence farmers may not be able to satisfy their basic needs, if water-right trading schemes are introduced and water prices increase (Masters et al. 2013). However, irrigation is – at least in Australia – not necessary to meet basic needs since irrigated crops are often exported from Australia and crop production could be confined to climatically adapted crops that do not need to be irrigated.

Hence, the applicability of the Australian water-right trading system to other regions in the world depends to a large extent on contextual factors such as the availability of financial support during extreme situations or alternative employment options for farmers.

The experience of other countries with water-right trading schemes, for example, Chile, the United States (California), and Spain, shows similar environmental problems to Australia, especially during times of drought. For this reason, Spain introduced Public Exchange Centres (Water Banks) that buy seasonal water rights to recover over-exploited water bodies (Garrido 2012). Here again, the necessity to restrict water extraction becomes obvious since markets just coordinate a specifically defined volume of water supply. If this volume is set inappropriately high by state governments, unsustainable water consumption is likely to be the consequence. Chile's water-right trading system is characterised by a less restricted market approach, in the initial phase of the system the extracted water was not even limited. This has led to an economically very effective use of water, but to an extreme overuse of water resources and an unsustainable transfer of water. In South Africa, the water market was combined with ecological water reserve management, which led to an allocation to high-value water uses as well as maintenance of a sustainable minimum level of water in the rivers (Takaya and Fleskens 2014).

In the case of the Australian Murray-Darling Basin, water allocation has to be coordinated only within one single country. In many other cases, river basins extend across borders, where neighbouring countries may not be willing to coordinate their water extraction levels. For instance, Namibia is a downstream water user of the Orange River and dependent on South African decisions about water consumption and treatment. Based on the Australian experience, it is important to coordinate water extraction on a basin scale, in order to achieve sustainable extraction levels and to establish a working water-right trading market.

Institutional arrangements, stability of political systems, good education and financial stability, the structure of the industry as well as the existence of a solid social security system determine the success or failure of water management strategies. It has to be considered carefully whether the Australian water-right trading system can be applicable to other countries and which social, ecological, and economic consequences this would have.

Conclusions

Water-right trading in Australia has been implemented to coordinate water demand and supply. While, from an economic point of view, the trading of water rights between farmers helps to allocate a scarce resource efficiently, allocation efficiency might not be achieved and consequently water wasted when trading rules and other market interventions lead to inflexibilities and limit trading activities.

Water-right trading re-allocates water to the highest value users, and it increases farmers' flexibility in the short term. In times of drought, this may lead to a reduction of cultivation area and a switch towards less water-dependent crops. In times of abundant water, irrigated agricultural area could be expanded and even crops with high water requirements could be cultivated if the recovery of water bodies could be ensured.

Despite these advantages, this article identifies barriers for allocation efficiency that may occur when the trading scheme is not flexible enough.

Since two conflicting goals have to be pursued, sustaining a minimum level of water in rivers as well as supplying farmers with sufficient irrigation water, trading of water rights has to be combined with limiting the overall volume of disposable water. The defined cap must therefore be adjusted to seasonal conditions that consider fluctuations of water availability and must include not only regional, but also basin-wide conditions of water bodies to meet sustainability criteria. In the past, these caps at different levels of the Murray-Darling Basin were not tight enough and thus led to environmental damage, particularly in times of drought. The new *Basin Plan* and the Australian Commonwealth governmental purchases of water access entitlements are meant to correct past imbalances. It remains to be seen whether these measures are sufficient to assure sustainable water use.

If overall water supply can be restricted at sustainable levels, water-right trading is a promising solution for achieving economic, social and environmental objectives. In the Australian case, it helps farmers to better adapt to weather variability and climate change, and it may even be a suitable option for other countries with appropriate economic and political conditions.

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