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How to reallocate water rights when environmental goals conflict with existing entitlements

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Abstract

Emerging concerns for environmental flows translate into reforms which aim to preserve minimal flows in rivers. These policy measures have consequences for traditional right-holders: how to share between consumptive users the new scarcity created by the protection of instream flows? In most cases, public water agencies have sought to implement temporary or permanent reduction of rights with partial or total compensation to affected water users. The range of solution varies within the existing legal, regulatory and institutional frameworks, from public takings to public buybacks, with also a series of in-between strategies such as voluntary agreements, compulsory acquisitions, constrained negotiations, and participatory decision-making. This article compares different policy mechanisms in France, Australia and California in an attempt to answer the questions of how to allocate water restrictions and compensations and how to pursue simultaneously efficiency, equity and acceptability objectives. It measures the shortcomings and advantages of different voluntary approaches: auctions, contracts and negotiations.

Key words

Instream flow

Voluntary agreement

Water management

Water rights (France, California, Australia)

Introduction

Water management policies until the late 70s relied mostly on the development of diversion and storage facilities. The main objective was to increase the availability of water supplies to households and agricultural producers. The flagship phrase, “not a single drop of freshwater should reach the sea,” led the way for policymakers as a benchmark measuring water infrastructure efficiency.

There has been a radical change in societal views of freshwater resources in the last 25 years. This progressive shift in social preferences has translated into increased demands for recreation, aesthetics and species conservation, all of which rely on the maintenance of instream flow. These shifting views have produced new ecologically sensitive laws, regulations and policies.

As legal and regulatory frameworks evolved, new priorities have been given to instream flow. However, policy language often gives little reference to how this objective should be achieved ¹. Policymakers now are faced with questions of how these new priorities should be incorporated into existing water allocation structure. Three types of solutions have been proposed:

- Historically, the most often used response is the increasing of water supply (by increasing storage capacity of water in the rainy season for use during the drier months) coupled with improved efficiency of water use. However, the era of large dam building is over (save for the Three Gorges Dam on the Yangtze River in China), due largely to budgetary constraints, but also because of strong opposition of such projects by environmentalists and local inhabitants ². Increased efficiency lies in the development of new irrigation technologies, such as drip irrigation, and new varieties of crops that require less water. Unfortunately, while surface water capacity may be increased by these responses, groundwater resources may suffer due to decreases in infiltration, which may ultimately contribute to a loss of instream flow ³.
- Another solution entails giving the environment *a priori* right to consumptive use, potentially creating a reliability problem for entitlement holders, according to scarcity-sharing rules of the existing water rights system (use license, access rights, entitlements, allocations etc...). In fully appropriated rivers, instream rights are often not met, in which case the government might resort to regulatory takings, and/or impose *pro-rata* reductions on existing rights.
- The third solution is to apply an equivalency of rights between environmental and other uses of water. This is done “so that trade between environment and consumptive use is possible” ⁴. Market transactions or other forms of voluntary agreements between traditional right-holders and the governing institution, in which environmental water rights are vested, could then be used for reallocation. This requires a definition of “environmental use” and society’s willingness-to-pay for the service this provides.

These answers are not mutually exclusive, as policymakers have often used a variety of combined responses to water scarcity. The frequency and level of scarcity guides the definitions of instream flow and environmental services, the nature and strength of existing water rights, and existing provisions of the public trust doctrine, and probably most importantly the political power of entitlement holders.

With this perspective, the objectives of the paper are to analyse how three different countries have dealt with the issue of water reallocation for environmental purposes. The three case studies are the Central Valley in California, the Murray-Darling Rivers in Australia and the Adour River in France. The comparison of these examples shows that governments prefer voluntary agreements for water management, even when more legally stringent solutions exist. The second part of the paper describes these voluntary programs (negotiations, buybacks and contracts) and compares their relative performance in terms of allocation efficiency, budgetary costs, administrative costs and information needs.

1. Water rights systems, regulatory frameworks and reallocation of water

This section describes the three case study basins. Commonalities lie in massive consumptive uses which have depleted water resources, affecting both surface and groundwater quality, thus altering the ecological balance in the catchments. The tyranny of the *status quo* accelerated tensions between water uses and postponed the much needed reforms until the early 1990s. Hence, reallocation of water rights and water use licenses to guarantee “environmental flows” during times of scarcity or drought have become the central focus of water management reforms. What constitutes an “environmental flow” is often a point of debate, as some argue that this should be based on the bare minimum to sustain aquatic life, while others may say that it should allow for seasonal flooding to mimic the natural cycle of rivers. Over-commitment of water resources lays the foundation for conflict between both irrigators and other water users, as well as among irrigating groups. Policy options adopted to respond to questions of reallocation are quite different, as it relies on the existing legal and regulatory arrangements that define, allocate, administer, monitor and enforce water entitlements.

1.1 Comparison of institutional setting and solutions

This section describes the main differences between the legal and institutional frameworks governing water rights and water-related activities. It shows how these differences have fostered different solutions to the issue of environmental flows enforcement.

“Prior appropriation”: in California, as in most of the western United States, water rights pertain to the appropriation doctrine. It is a use-based rather than land-based system of property rights which traditionally applied to direct flow diversions (and later to the storage of water for subsequent release) on the basis of the pioneer principle “first in time-first in right.” Water rights are appropriative rights, attenuated only by three historic limitations: (i) unused rights are subject to abandonment or statutory forfeiture, (ii) the use of rights must not be wasteful, and (iii) the use of rights must be for a beneficial purpose. In times of shortage, rights are allocated by priority:

holders of senior rights are entitled to take the full amount of their rights regardless of what is left for junior right holders, which are cut back accordingly.

However, the original appropriation doctrine has been progressively supplemented by administrative management regimes defining rules for the allocation and distribution of water, in order to manage better conflicting uses and to meet multiple objectives. The Californian law has imposed that all rights appropriated after December 1914 (the so-called *junior rights*) be assigned and administered by a state agency, the *State Water Resources Control Board (SWRCB)*. The candidate appropriator must demonstrate to the SWRCB that (i) unappropriated water is available, (ii) the proposed appropriation will not interfere with prior rights, and (iii) the appropriation is in the public interest. The public is notified of the demand, at which time it can be challenged by other users. There is also a judicial procedure of right adjudication in case of conflicts. This procedure is often slow and the conclusions reached can be challenged in court, both in other jurisdictions and/or by appeals.

Existing water rights are currently being challenged by several federal environmental laws such as the 1972 Clean Water Act and the 1973 Endangered Species Act, which specify that water quality and biodiversity conservation objectives are to be granted priority over economic interests. Such laws have created federal regulatory rights to minimum flows. They have the potential to displace existing rights since they require States to reconsider the allocation of water in order to improve instream flows and water quality. However, the margin for manoeuvre for the States remains thin: senior rights are constitutionally well-protected rights and although the Californian State retains some power on the status of junior water rights, the threat of judicial procedures narrows down the scope of administrative discretion ².

“Administered exchangeable rights” in Australia, water rights are administered on the basis of a patchwork of statutory and riparian common law. The Crown is given overall power to control the use of water and to manage any consequence of its use. Therefore, the use of water for purposes other than domestic use (including garden watering) requires a license, which is allocated by the Crown agency. Licenses are issued for a specific period and can be revised or cancelled at the end of the period, although, normal practice is to renew licenses when they expire, there is no guarantee for replacement, renewal or compensation.

State governments can alter water entitlements either by enacting new legislation or by adopting regulatory provisions on the scarcity-sharing rules in periods of low supplies. For example, in South Australia where water supply is of relatively high security, the government is entitled to temporarily readjust water allocation through proportional curtailment (similarly to the French system). In New South Wales, there are high security and low security (general) entitlements. If water supply is low, the high security entitlements are satisfied before and the low security entitlements bear the brunt of the restrictions ⁵.

The license system has been regularly criticised for its lack of flexibility and its failure to allocate water to its most efficient uses. In the context of increasing competition for scarce water resources, a number of policy changes were adopted in the hope of favouring a more sustainable management of water. These policy measures entailed, among other characteristics, the partial

transfer of property right management down the institutional hierarchy (i.e. from state government to community-based water management committees in each catchment). The objective was to improve participatory decision-making processes, therefore reducing conflicts and inefficiencies associated with lack of information.

However, the main impetus for reform came from the Council of Australian Governments agreement (COAG), which endorsed a strategic framework for the efficient and sustainable reform of the Australian water industry in February 1994. COAG agreed that each jurisdiction would clearly specify rights in terms of ownership, volume, reliability, and transferability. The guiding principles of the water rights reform were twofold: (i) to separate water entitlements from land titles in order to foster water markets in the form of water entitlement sales or leases, and (ii) to recognize the environment as a legitimate water user, which entailed that environmental contingency allocations could be imposed by state authorities. It was clearly specified that “where environmental water requirements cannot be met due to existing use, action (including re-allocation) should be taken to meet environmental standards” and the water users should be duly compensated for the losses.

Each Australian State had to reform its water rights law accordingly. In most States, provisions for compensation clauses were adopted in order to preserve incentives for investments in irrigated farming. However, farmer groups still find the new water-sharing plans threatening and have repeatedly asked for more “voluntary buyback schemes” for more security in tenure and for less flexibility and administrative power retained by States ⁶. The reform process has, in fact, run into a dilemma which has introduced major ambiguities in the final reform plans. The necessary reinforcement of water rights, in order to implement efficient water markets, runs contradictory with the necessary attenuation of rights in order to allow States to reduce entitlements in the name of environmental protection. As R. Challen ⁷ has emphasised “strong private property rights may reduce the capacity of a regulatory agency to make unilateral decisions for altering water entitlements in years of low supply, forcing the government either to buy back entitlements or to bear a cost through compromised environmental objectives”.

“Administrative licence allocation” in France, navigable watercourses pertain to the public domain. The State is entitled to their use and control. Public water agencies (one for each hydrological system) grant water use rights to private parties (individual water users, private corporations and trusts, irrigation-scheme groups) through temporary licenses. As a counterweight to the growing conflicts occurring in times of scarcity, the 1992 water law has declared that all water resources are part of the “common heritage” of the Nation and must be managed as a common pool of resources. It has, therefore, generalized the enforcement of use licenses, including groundwater use and has re-emphasised their usufructuary nature ⁸.

“Use licenses” are, theoretically, delivered annually for a given discharge and a given usage by the State agency of each jurisdiction, and cannot be traded or leased. The agency is expected to check that the state of the resource is sufficient to satisfy all other existing licenses, as well as, minimum requirements for the environment. In practice, the control of uses has been insufficient, leading to over-allocation and severe summer scarcity in certain areas. Moreover, although the licenses are potentially renegotiated each year, it is extremely rare that a license is not re-granted. Therefore, there is an underlying seniority principle in the allocation process. All new demands

are managed through a waiting list, the new available volumes being most often granted by order of solicitation.

Early national legislation introduced the principle of minimum quotas for the environment in 1964. In times of scarcity, minimal flows have to be left in rivers to preserve aquatic life. The remaining water is shared out on a proportional basis between other users, mainly agriculture and industry through temporary restriction roster systems managed and controlled by public authorities.

Therefore, water rights in France are substantially attenuated and relatively insecure. They are contingent both on the state of nature and on the decisions of the State. The principle of annually renewable licenses tied to a specific use excludes an interpretation of water rights as exchangeable titles.

1.2 The solutions to environmental flows

The Central Valley in California is a vast hydrologic basin of nearly 700 km. The two main rivers are the San Joaquin River and the Sacramento River which flow along the Sierra Nevada and join to form the Delta flowing into the San Francisco Bay. This huge basin drains more than half of California's water supply and one third of this water is used by farmers. Despite the massive reservoir dam infrastructure financed by federal and state funds, water resources are stretched between environmental needs, massive pumping for irrigation purposes, and an ever increasing demand for domestic use, associated with a rapidly growing urban population. Excessive consumption of water has worsened the nutrient pollution issue and it has dramatically reduced downstream flows, allowing the intrusion of saltwater into the estuary. The Bay-Delta area formerly known for its wetlands and biodiversity has been adversely affected and the overall ecosystem is under threat.

To respond to the requirements of federal laws, and more specifically to the Endangered Species Act, the State Water Resource Control Board (SWRCB) has been seeking since the mid-eighties to establish a long-term water management plan. The objective was to increase instream flows through the reduction of allocations to agricultural and urban areas. The five-year long drought from 1987 to 1992 heightened the impetus to the reform program ⁹.

Schematically, two broad alternatives were initially envisaged: (i) *the secure water right alternative* gave entire priority to senior rightholders by reinforcing existing water rights in order to foster water markets and to let the competitive forces redirect water towards its *highest value* uses; (ii) *the fair alternative* was to authoritatively reallocate water rights in favour of the environment as well as in favour of *most beneficial* uses such as domestic uses and high value crops.

Since the former solution was rejected by the Californian governor at the time (who protected the interests of Southern agribusiness and city districts), Californian public authorities have adopted a cautious approach to the fair alternative through a mixture of regulatory actions and voluntary participation schemes, implicitly avoiding a permanent cycle of authoritative decision-making

and judicial litigation. They chose, therefore, to foster a high degree of stakeholder involvement through negotiations and participatory approaches.

A negotiation structure termed *CalFed* was created and dually supervised by the State of California and the Federal government. It oversaw the so-called “three way negotiations” between farmers, urban dwellers and environmentalists ¹⁰. A first framework agreement was reached in December 1994, the Bay-Delta Accord, which imposed water quality standards in the Bay-Delta, and defined overall maximum restrictions for dry years and maximum consumption volumes monthly. This agreement was heralded as a milestone since it was one of the first coordinated steps to restore the delta ecosystem.

The second phase of negotiation, which started in 1998 after the publication of several expert reports, focused on ways to allocate the global restrictions which were agreed in the first phase between individual stakeholders. Water right hearings were conducted under the supervision of the SWRCB, which tried to encourage local agreements. It ended in December 1999 with a SWRCB final decision which put together all the partial agreements that had been reached. However, most recently the initial successes have been undermined by CalFed’s announcement that a formal decision on the Bay-Delta water management plans might be delayed for another few years.

The negotiations were also accelerated and supported by a number of Federal and State buyback programs. Since the signature of the Central Valley Project Improvement Act in 1992 ¹¹, the procurement of water for environmental purposes has represented a significant share of the local water market activity in the Central Valley of California ¹². The Fish and Wildlife service and the US Bureau of Reclamation have been actively acquiring water for environmental purposes: either on a short-term basis (to assist the out-migration of salmon) or on a longer term basis to guarantee a more sustainable ecosystem for fishes. Most buyback programs have been funded by the Federal Restoration Fund. In the early 1990s, the California Water Banks also made standing offers to acquire water during drought years.

This case study shows that the impetus for reform of water allocation patterns was initiated by federal environmental legislation which rendered more credible the “takings” threat and forced stakeholders, especially senior rightholders, to behave more cooperatively in search of a negotiated outcome. The improvement of the Bay-Delta instream flows were obtained through a mixture of negotiations and purchase programs, with relatively little regulation.

The basin of the Murray-Darling Rivers extends over four Australian States (Queensland, New South Wales, Victoria and South Australia). It is an important source of freshwater for domestic consumption, industry and agricultural production (almost 75% of the total irrigated land in Australia). It also has high environmental value with extensive wetlands, and a rich aquatic life. Major water storage infrastructures have been constructed on the rivers. However, although these developments were needed to create economic activities in the basin, they also caused irreversible changes to natural flows ¹³ and resulted in major ecosystem damages. Tensions have mounted not only between production-orientated activities and environmental needs, but also between competing farming interests.

To help resolve the issues of water sharing and river management between Victoria, New South Wales and South Australia, an interstate framework for political and administrative cooperation was created: the Murray-Darling Basin Ministerial Council and the Murray-Darling Basin Commission (MDBC). The water is shared between the three southern basin states on the basis of the Murray-Darling Basin Agreement principles. States then allocate water entitlements to group irrigation schemes and individual irrigators through volumetric licenses. These efforts were primarily in response to lack of consistency between state legislation.

A series of reforms initiated in the 1970s have substantially strengthened the water tenure of irrigation farmers, mainly in the form of enhanced security of water supplies and through the introduction of the transferability of water entitlements. This has reduced the ability for regulating agencies to alter patterns of water use and water entitlements. When tackling emergency scarcity, they could only have a limited recourse to regulatory instruments and often had to rely on voluntary agreements and buyback programs, at the expense of the taxpayer. This was all the more costly as water has been consistently over-allocated in the past thirty years, thus aggravating the risk of scarcity.

In 1997, the Murray Darling Basin Commission agreed on a “cap” to limit irrigation development at 1993-94 levels and decided on an allocation for helping environmental flows of up to 10% of average annual diversions. As a consequence, due to low water supply in the Murray region in 1998, the New South Wales government had to release water from the Snowy Mountains scheme and reduce its production of hydroelectricity. They also had to negotiate a compensation package with farmers in exchange for reduced water allocations by 4 to 12% to provide for environmental flows ⁷.

In 1998, the Commission established a Project Board to look further at environmental flows and water quality issues. The objective was to develop a flow management plan for the River Murray by mid-2001 with the participation of the communities, the industries and jurisdictions concerned. Three options for increased environmental flows were considered and in April 2002 a rescue package was agreed upon that could result in up to 1,500 gigalitres of water being restored to the Murray River: although legal provisions allow federal authorities to impose across-the-board restrictions, the state and federal governments have agreed to share the cost of farmer compensations, which might include funding water efficiency measures, water buyback schemes and water purchases through the open market (COAG September 2003). Although this decision has been welcomed by environmental groups ¹⁴, it is challenged by community groups, which argue that the Murray River environmental flows could cost the taxpayer more than \$5.2 billion.

The provision of environmental flows in the Murray-Darling River basin is a recurrent issue, which has required many years of negotiations at the interstate level as well as the local level. It is being solved progressively through negotiated agreements and compensation packages, as well as massive investment (for salinity) and short term buyback programs at the expense of public finance. Although it may have contributed to improve the efficiency of water use, the successful development of water markets has been partially counterproductive because it has increased the opportunity cost of unused water, making all buyback programs more costly. To counteract this difficulty, a number of authors ^{4, 15} have suggested that new property rights be in the form of

shares, that is a proportion of available water resources in the catchment. The environment could also be entitled to tradable shares and would participate to the “stock market”.

The Adour Basin in the southwest of France is one of the main irrigated agricultural areas in France with 138,000 ha under irrigation. It is modest in size when compared to the Australian and Californian catchments. The uptake of irrigation in the Adour area started 20 years ago, when farmers switched to irrigated maize, encouraged by European subsidies and very low water fees. The massive growth in agricultural use has created severe deficits during summers, endangering the ecological balance of the river and limiting drastically its recreational use, especially in the upstream sub-catchments. Tensions have been mounting between farmers, local communities, and environmental groups. Moreover, the Adour River crosses several administrative jurisdictions (the so-called *departments*) which have been enforcing different scarcity-sharing rules, leading to growing discontent and competition between water users.

In the wake of the decentralization process, initiated in the early 80s, the 1992 water law strengthened the role of local stakeholders by defining specific negotiation and participatory procedures for defining local water management regulations. Specific water development plans had to be developed for each of the six French hydrological basins before the end of 1997. These 10-year water plans (called *Schéma Directeur d'Aménagement et de Gestion des Eaux* or SDAGE) were drafted at the regional level with the participation of local authorities and civil society representatives, and imposed a number of constraints in terms of instream flows, total consumptive use, planned infrastructure and pricing rules. The law specifies that each sub-catchment area can then initiate a negotiation procedure between all local stakeholders to decide collectively how to reach the SDAGE objectives in their area.

In the Adour case, stakeholders were charged with determining the size of three reservoir dams: public authorities offered to pay for the corresponding investment costs, provided an agreement could be reached on how to re-allocate water supplies (for different scenarios of water scarcity) and water fees, in order to respect the SDAGE requirements concerning minimum environmental flows and full cost recovery rules. The negotiation process started in 1998 and reached an initial settlement a year later on the guiding principles governing the cooperation between stakeholders: they agreed to finance research studies to evaluate future needs and supplies; they defined a total water volume for consumptive use in the sub-basin and farmers accepted to contribute substantially to infrastructure use and maintenance costs. However, working out the details of this initial plan has proved to be prone to conflict: the allocation rules between farmers and a scarcity management plan are still under negotiation.

It is interesting to note that the devolution is however strictly supervised. In fact, the negotiated decision-making process is closer to a debate than to a genuine devolution process: public authorities closely watch the negotiation and define the structure of the negotiation table; the state representative remains the last resort decision-maker and is entitled to impose tight constraints which restrict the boundaries of the solution space.

1.3 Summary of case studies

The three case studies display water right arrangement systems ranging from very attenuated rights in the form of non-exchangeable annual renewable licenses in France to constitutionally protected, appropriative and exchangeable senior rights in California. Australian water rights are a mixture of strengthened water rights allowing trade and lease as well as regulatory attenuation allowing States to alter the initial allocation in order to respond to environmental needs.

One could expect that this hierarchy of water right strength would translate into a hierarchy of solutions for water re-allocation, from more regulatory top-down measures in France to voluntary agreements and buyback programs in California. However, one of the most striking conclusions is the priority given in all cases to participatory processes, negotiated agreements and voluntary participation programmes. There are several other common points. In the three case studies, the implementation of minimum instream flows is triggered by state or federal environmental laws which create public regulatory rights allowing permanent reduction of water entitlements. Implementation takes place in two phases: in the first negotiation phase, collective restrictions are agreed upon. In the second phase, public authorities turn to voluntary schemes in order to allocate restrictions and compensations amongst existing users. In France, it is a devolution and negotiation process at the sub-basin level; in California and Australia, it is a mixture of negotiations, buybacks and redefinitions of rights. However, minimum environmental allocation remains a politically negotiable variable, which can be re-adjusted during the decision-making process following the unveiling of conflicting interests, the confrontation of stakeholder perceptions and the gradual build-up of common interests.

2. Voluntary settings for re-allocating water

The preceding case studies have shown that public authorities are reluctant to authoritatively implement regulations which would result in significant reductions of water entitlements or allocations without fair compensation to water users. Even where the water right system would allow compulsory takings, public authorities favour re-allocation programs based on voluntary participation by right-holders. One of the reasons lies in the difficulty to ensure that the decision is politically acceptable and therefore enforceable. Stakeholders for whom water is a vital input for the production process are likely to oppose allocation reforms which would result in significant business losses or a reduction in water access security, thereby increasing production and investment risks. Farmers are particularly sensitive to this issue and most water allocation reforms affecting irrigated agriculture involve negotiated agreements or voluntary commitments by farmers.

We distinguish three ways of reallocating water on a voluntary basis: devolution and negotiations, buyback programs, and contracts.

- Devolution and negotiation require the State to identify water user groups (usually at a watershed scale). Each group is assigned a quantitative objective in terms of total water

use reduction and is offered an overall *compensation*. The compensation can be monetary and allocated individually but is most often offered as an indivisible prize, such as the financing of new collective infrastructures or extension programs. Water users in the group are empowered with the responsibility to define their own management rules, and to govern and enforce allocation of water amongst themselves.

- Buyback programs assume that transactions take place between a state agency and right-holders, selling permanently or temporarily their water licenses for a *price*, which can be defined through the market process, a bilateral negotiation between the seller and the purchaser (when markets are thin), or procurement auctions.
- Contracts are signed between the state and farmers specifying a given *subsidy* for a pre-defined form of renouncement to water for a given period, which may include; fallowing the land, switching to a more water-efficient technology, adopting cropping patterns which are less water demanding, foregoing irrigation, etc.

As has been emphasised in the case studies that policy-makers often choose to implement a mix of policy instruments at different levels. It is therefore useful to provide them with some guidance on the relative performance of these voluntary settings, with a critical review of the existing theoretical literature. The classical economic indicators of performance are efficiency and budgetary costs. Water is said to be efficiently allocated among uses when the net benefits from all its competing uses are maximised. Budgetary costs are linked to the problem of information asymmetries between the decision-maker and right-holders. If the decision-maker knew exactly how much it costs for farmers to forego irrigation water, he would offer a compensation which would just offset their losses. A lower compensation would preclude voluntary participation by farmers, while a higher compensation would achieve the desirable goals in terms of water saved, but at perhaps too high a budgetary cost. In fact, in most cases, the policy-maker is not well informed about the individual cost structure of each irrigator (or information is too costly to collect) and there is a risk that overcompensation may occur. The challenge when designing allocation and compensation mechanisms is therefore to provide incentives for truth-telling by farmers, without deterring participation.

In the following part, we describe in more detail, the main implementation issues associated with each of these voluntary settings. A brief review of the theoretical literature provides indications on their expected performance.

2.1 Devolution and negotiated decision-making

Governments increasingly rely on local communities to design and enforce their own water management rules at the catchment level through negotiated decision-making procedures. More than a decentralization process, which is a transfer of responsibility from the central government to its local agencies, this implies an explicit political devolution process by which more autonomy and independence is granted to local stakeholders. In this context, the central government can choose to impose a number of constraints on the negotiated issue space. Typically, it will set a minimal flow constraint at different locations and times in the catchment

area and will offer a collective “reward” in the form of monetary transfers which are to be paid only if stakeholders reach an agreement on a water management plan, thus defining burden and gain-sharing rules.

The first advantage of devolution is that the state does not need to acquire detailed knowledge on the preferences and costs of stakeholders since they are left to negotiate between themselves. Since the transaction costs, in terms of delays, information needs and conflict resolution procedures are borne by the group, there is a strong incentive for the group to cooperate in order to rapidly reach workable compromise solutions. It is also believed that when implementation is monitored by the group, compliance is better due to collective and mutual control ¹⁶. It is also argued by psychological and sociological studies that participatory processes and negotiations contribute to the promotion of mutual understanding, align misperceptions and build collective values, thereby fostering cooperative behaviour. The expected benefits of a locally negotiated decision are, therefore, the improved accountability of stakeholders and increases in legitimacy of the decisions, which translates into easier implementation, less litigation and improved stability of agreements ¹⁷.

However, devolution can also lead to deadlocks and unresolved conflicts, perhaps evolving into endless debates. One of the factors which contributes to the possibility of a successful integrative bargaining process is that stakeholders possess multi-attribute and independent preferences, which provide a greater capacity for trade-offs ¹⁸. It also helps if the area size of the catchment, within which the negotiation is organised is not too large, allowing the effects of reputation, reciprocal concessions and other social network benefits.

The main difficulty with negotiations lies within biases and equity issues linked to the structure of the negotiation. The bargaining power of stakeholders depends largely on the negotiation setting ¹⁹: the composition of the negotiation table (who is invited and on what basis), the definition of the issue space (what are the negotiated variables), the decision rules (unanimity rule versus majority, essential player), the sequencing of the negotiation (is it a whole package agreement or can it proceed through partial sequential agreements). It may lead to undercover negotiations on the “rules of the rules”. It may jeopardise transparency and lead to frustrations and inefficiencies in the bargaining process.

Economic models used to simulate the negotiation process and to serve as negotiation-support tools are rapidly developing ^{20, 21}. Adams et al ¹⁰ and Thoyer et al ²², for example, develop a multilateral bargaining model to calculate the outcome of water negotiation processes in California and in the South of France, respectively. Such modeling process incorporates multiples players and a multidimensional issue space (N players gather to negotiate over a given set of K policy variables x_k). Each player is characterized by a pre-defined payoff function (called utility function) with respect to the negotiated variables. The negotiation is organized as a sequence of games with finite bargaining horizon. At each round t , a player j amongst the N players is chosen randomly with a given access probability a_j and makes a proposal X_t^j over the policy variables. All other players i calculate the utility U^i they derive from this proposal and compare it with their reservation utility EU^i . A player's reservation utility is the utility he can expect from the following round $t+1$, which is the sum of the player's utilities derived from each player's proposals (including himself) in the next round, weighted by their access probability.

Players choose to move on to the next round when their reservation utility is higher than the utility derived from the proposer's offer. A compromise is reached when all players agree on a proposed set of policies X. The game then ends. The interest of such models is that they can be used to simulate the negotiation outcome under different scenarios of negotiation structure. However, their interests are limited since they are based on the assumption of perfect information and they only allow Pareto-improving solutions.

2.2 Buyback programs

Water acquisition programmes by public authorities (or in certain cases by environmental groups) have taken place regularly since the early 90s in the US and have the potential to be implemented in Australia. The procurement of water for environmental purposes has represented in certain states such as California or Nevada a significant share of local water market activities¹². Since markets are usually thin, the most common form of transaction is bilateral negotiation²³. However, it involves high transaction costs and may result in the payment of excess prices when the purchasing public agency is ill-informed about the true opportunity costs of the seller or when the potential sellers enjoy a high market power due to their position in the river or some form of collusion. Moreover, since the price at which a transaction takes place becomes public information, there is a risk that bilateral bargaining will result in the establishment of a price floor which might be detrimental to the outcome of other following negotiations. Speculation might also be a problem when right-holders expecting a more intense drought period, choose to retain their rights in order to get higher prices later. The advantages however are that the buyer can select the sellers and the acquisitions that will provide the greatest level of environmental benefits.

This is not the case with purchasing programmes through posted prices or other forms of standing offers. This process has the advantage to imply lower administrative and information costs and is also considered “fairer” by water right holders since participation is open to all potential selling candidates. However, the drawbacks are numerous. Posted price offers are not flexible. This usually hinders the regulating agency from acquiring water selectively according to greatest needs unless it can practise price discrimination (in terms of location or timing for example) and there is little scope for fine-tuning. Too high an offer will end up in excessive budget spending, excessive water purchase and a high rent amount paid out to sellers. A well-known example is the California Water Banks, which sought to acquire water during drought years in the early 1990s through standing offers. In 1991, the purchases exceeded the sales leading to a huge carryover of water in the bank into 1992⁹.

More recently, states have tried to rely on more competitive processes in order to reduce information rents. A public agency solicits offers from individuals or irrigation districts to provide additional water for environmental purposes. The auction design varies but usually involves sealed bid offers. The advantages are that the public agency does not have to acquire information about sellers and may in fact gain information by observing the bids. Moreover, it can adjust the bid ranking procedure so as to select the offers which suit best its demand, through a scoring function. It can also adopt a more sophisticated auction design in order to foster participation and to deter mark-up strategies. In Georgia, for example, an iterative sealed offer

discriminative auction was held in 2001 in the Flint River Basin. Farmers submitted offers (a per acre price at which they were willing to suspend irrigation under a given permit for the remainder of the calendar year) which were ranked. A cut off price was determined and provisional winners were announced (without giving away the cut off price). All farmers were free to submit a revised offer. The iteration was ended when no revised offers were made. Several hundreds of farmers participated and 33,000 acres were temporarily taken out of irrigation to increase instream environmental flows ²⁴.

The literature on auctions is extremely vast and provides useful insights into the optimal bidding behaviour of bidders. There are increasingly used by the public sector to buy environmental services or access rights to natural resources from private stakeholders ²⁵. One of the main issues with auctions is the risk of collusive behaviour by sellers, especially when they are not numerous or when they are linked through strong social networks which favour communication and trust ²⁶. ²⁷. The advantages of competition can also be jeopardized in a framework of repeated auctions, which provides sellers with past information on their competitors' values and behaviour, and on the auctioneer's reserve price ^{28, 29}. The lack of sufficient familiarity of farmers with the auction process is also an obstacle to participation and adequate bidding, especially when the chosen auction design is complex. It may often necessitate preparatory meetings, information campaigns and trials.

2.3 Water-saving contracts

By signing a contract, the farmer makes a commitment to adopt water-saving practices and/or technologies for a given period in exchange for government payments. The payments are expected to compensate for additional investment costs and for any loss in profit resulting from the changes of practice. Contracting is widely used in the European agri-environmental programme. It is a policy mechanism which is usually adopted when it is easier to monitor processes rather than outcomes (like in the case of non-point pollution or the improvement of biodiversity). In the case of water, contracts which would subsidise farmers adopting water-saving technologies or practices would be more adequate than buyback programs when it is difficult to control the volume of water used by farmers or when water entitlement trading is not legally permitted. It should be noted that farmers are often reluctant to sell or lease their water rights on a temporary basis for fear that their rights may be confiscated on the grounds that they are not making a direct beneficial use of them. In such cases, contracts are more acceptable solutions to farmers since they usually do not jeopardise the security of their entitlements.

However, contract design must deal with the issue of asymmetric information. Due to the hidden information problem, the regulator takes the risk of offering transfer payments which are well above the true opportunity cost of farmers. To take account of this information asymmetry problem and of the heterogeneity of types of farmers, the theoretical literature on optimal contract design suggests that a menu of contracts (specifying a given water-saving behaviour and a transfer payment for a given farmer type) be designed in such a way that the best option for farmers is to behave sincerely and to pick up the contract corresponding to their type ³⁰.

Contracts and auctions are not equivalent because they do not require the same level of information. To be able to design an optimal contract (which minimises the social losses), the regulator needs to know what the compliance costs are for each type and what the proportion is of each type in the area. On the other hand, the regulator does not need to know anything about farmers' profit functions when designing an auction mechanism, and the bid answers will provide him with an updated information base (although it may be biased, since farmers may adopt a strategy of overbidding; it may also be incomplete since the regulator will not have information on the non-participating farmers).

3. Conclusion

Emerging concerns for environmental flows – for biodiversity conservation, habitat and landscape preservation, and recreation – translate into a number of legal, regulatory and policy measures which aim to preserve minimal flows in rivers. These policy measures have consequences for consumptive users since they create an artificial scarcity which must be shared between traditional water right-holders. The three case studies show that although the water rights legal and regulatory frameworks usually allow the state to carry out compulsory takings in order to protect environmental stakes, public authorities prefer to adopt more consensual policies based on voluntary participation schemes and negotiation procedures. This is obviously more costly since it entails that compensation payments be paid out to entitlement holders, but it has proved to be more politically acceptable. However, selecting the best policy design is a key issue and involves measuring the potential trade-offs between the efficiency of allocation (maximizing the net social benefit under restricted access to water), the total cost of acquisition efforts, transaction costs (including reluctance to comply), and the regulator's information needs. Theory can provide some guidance to compare these instruments but it is also important to note that existing models are based upon strong assumptions about stakeholder behaviour and the distribution of information. They can therefore be useful for baseline simulations but do not allow to draw general conclusions. Thorough information and/or data collection about existing legal and regulatory frameworks, irrigators, industries, seasonal differences in precipitation, vulnerability to climate change, willingness-to-change within the community, and other characteristics are pivotal to the success of these voluntary agreements.

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