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

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draft[2]

Abstract

New concerns for environmental flows – for biodiversity conservation, habitat and landscape preservation, and recreation – translated into a number of legal, regulatory and policy measures aiming at preserving minimal flows in rivers. It has consequences on 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 (mainly irrigation 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, participatory decision-making, etc. 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 also emphasises the shortcomings and advantages of different voluntary approaches: auctions, contracts and negotiations. A numerical simulation based on a simple example allows to compare the efficiency and costs of the different mechanisms. Background theory is provided in appendices

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Introduction

Until the late 1970s, fresh water resources were mainly treated as an input for production purposes and as an essential household consumption good. Water management policies focussed heavily on the development of diversion and storage facilities to increase the availability of water supplies to consumers and producers. The flag sentence "not a single drop of fresh water should reach the sea" was used by policy-makers as a symbolic benchmark to measure water infrastructure efficiency.

The last twenty-five years have witnessed a radical change in the way fresh water resources are considered by society: there has been a progressive shift in social preferences which has translated into increased demand for recreation, aesthetics and species preservation, all depending heavily on water remaining instream. It translated into more ecologically sensitive laws, regulations and policies.

These evolving legal and regulatory frameworks are increasingly firm on the necessity to give new priorities to instream flows. However, they provide little guidance on the implementation mechanisms to reach these objectives (McKay, 2002). The question faced by policy-makers is how they should include these new priorities into the existing water allocation framework. There are three broad types of answers:

- The initial easiest solution is to increase water supplies (mainly by storing water during the winter months and by releasing it during the scarcity season) or to improve the efficiency of water use, in order to satisfy simultaneously economic and non economic needs. However, the era of big multi-purpose dams is over: the construction of new reservoirs is most often precluded by fiscal and budget constraints. Moreover, the increasing scarcity of appropriate sites and the fierce opposition of environmentalists and local dwellers who care for their landscape have also contributed to reduce dramatically the recourse to new infrastructure (Tarlock, 1997; Lord and Kenney, 1995). The solutions to increase the efficiency of use of diverted water range from canal seepage reduction to the adoption of new irrigation techniques (drip irrigation as opposed to flood irrigation) and of new varieties which require less water. However, these solutions usually contribute to reduce return flows to the river or the groundwater system (Gyles, 2003) and might in fact have the perverse effect of contributing to lower instream flows, especially when irrigators are entitled to keep the benefits of their water-saving adjustments in order to expand their irrigated area (Young and McColl, 2003).

- The second solution is to consider that the environment has a *prior* right to consumptive users and that it should get its share first, therefore potentially creating an additional reliability problem which must be borne entirely by entitlement holders, according to the scarcity-sharing rules of the existing water

rights[3] system. For fully appropriated rivers, where new instream rights cannot be met with an acceptable frequency, governments might resort to regulatory takings, and "confiscate" or impose administratively a pro-rata reduction on existing rights, in the name of the public interest.

- The third solution is to consider that the environment's interest are *equivalent* to the interests of other users and that water rights for the environment should be defined "so that trade between environment and consumptive use is possible" (Young, p42, 2002). Desirable changes in water allocations would then be obtained via market transactions or other forms of voluntary agreements between traditional right-holders and the institutions (usually public) in which water rights for the environment would be vested. The major issue is then to adequately define the nature of water environmental services and the willingness to pay for these services by the society.

These three interpretations are not mutually exclusive and policy-makers have been resorting to combinations of solutions. Their implementability depends very much on the level and frequency of scarcity situations, the definition of environmental flows and the needs for environmental services, the nature and strength of existing water rights, the existing provisions for the public trust doctrine, and the political power of entitlement holders.

Within this perspective, the paper is organized as follows. Three case studies involving water right re-allocation are described and compared: the Central Valley in California, the Murray-Darling rivers in Australia, and the Adour river in France. The case studies show that governments tend to avoid conflicts and seek to privilege voluntary agreements even when they can legally resort to more stringent solutions. In the second section, the theoretical advantages and drawbacks of different voluntary settings (negotiations, buybacks and contracts) are described. A numerical example is provided in the third section: it allows to compare the efficiency and the costs of each policy mechanism in a unified simplified setting.

1. Three countries, three types of water rights systems, three regulatory frameworks

The following section describes and compares three basins, which share identical problems: massive consumptive uses depleted the water resource, affected the quality of surface and underground water and altered the ecological balance in their catchments. Tensions between water users were accentuated by the well-known tyranny of the status quo, which postponed much needed reforms until the early 1990's. With management reforms under way, one of the most crucial issues in each of these three case studies lies

[3] We use the words *water rights* as a generic term encompassing all forms of water entitlements (use license, access rights, entitlements, allocations etc.)

in the re-allocation of water rights or water use license in order to guarantee higher instream flows in times of water scarcity or drought[4]: the over-commitment of water resources has laid the foundation for conflict not only between irrigators and other sectors of the community but between different irrigator groups on how the burden of water restrictions should be shared. The policy options which were adopted to respond to this reallocation issue are different, due to the existing legal and regulatory arrangements which define, allocate, administer, monitor and enforce water entitlements.

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 Western States of the United States, water rights pertain to the doctrine of "prior appropriation". It is a use-based rather than land-based system of property rights and it traditionally applied to direct flow diversions (and later to the storage of water for subsequent release) on the basis of the pioneer principle "first come-first served". 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 (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 rights, which are cut back accordingly.

However the original prior 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 (iii) the appropriation is in the public interest. The demand is publicly notified and can be challenged by other users. There is also a judicial procedure of right adjudication in case of conflicts. This procedure is usually fairly slow and the conclusions reached can always be challenged in court in other jurisdictions 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

[4] The issue of environmental flows is in fact more complex. Although in simple river systems, the priority is to guarantee minimal instream flows in order to preserve aquatic life, the protection of richer ecosystems (with wetlands or delta areas for example) might require to reconstitute « natural flows » or to re-create floods.

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 (Tarlock, 1997).

"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] (similarly to the Californian seniority system).

The license system has been regularly criticised for its lack of flexibility and its failure to allocate water to its most efficient uses. In a 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: it entailed, amongst others, the partial transfer of property right management down the institutional hierarchy (for example from state government to community-based water management committees in each catchment).The objective was to improve participatory decision-processes, therefore reducing conflicts and inefficiencies associated to 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

[5] Water availability to low security license holders is called an *allocation*. It is a proportion of entitlement announced at the beginning of the season (and potentially revised to reflects updates on water availability in the catchment) depending upon the resources available in storage.

that each jurisdiction would clearly specify rights in terms of ownership, volume, reliability, and transferability (ref voir Young). The guiding principles of the water rights reform were twofold: (i) to separate water entitlements from land titles in order to foster water makets 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" (ARMCANZ 1996) 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 (NSW's Irrigators' Council, 2002). 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 has emphasised (2001, p30), "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 license allocation" : In France, navigable watercourses pertain to the public domain[6]. The State is entitled to their use and control. Public authorities 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 for groundwater use, and has re-emphasised their usufructuary nature (Barraqué, 1995).

Use licenses are theoretically delivered annually for a given discharge and a given usage by the State agency of each jurisdiction. They 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 be not re-conducted. Therefore there is an underlying

[6] On the other hand, non public watercourses constitute a complex legal domain in which predominate landowner riparian rights.

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[7]. In times of scarcity, minimal flows to protect the environment (calculated as a percentage of water discharge etc..) and to guarantee the needs for drinking water are granted priority. 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 State's decisions. The principle of annually renewable licenses tied to a specific use excludes an interpretation of water rights as exchangeable titles.

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 supply water and one third of this water is used by farmers. Despite the massive reservoir dam infrastructure financed federally and by the Californian State, 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[8]. 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 which used to be famous for its wetlands and its 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 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 gave a new impetus to the reform program (Howitt and Vaux, 1995).

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

[7] the « *loi peche* » edicted in 1964, later reinforced by the 1992 water law, was the first to introduce regulatory minimum flows in rivers to protect aquatic life

[8] within the basin (San Francisco, Sacramento) and outside the basin (Los Angeles)

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 orchard irrigation.

Since the former solution was rejected by the Californian governor at the time[9], Californian public authorities have adopted a cautious approach to the fair alternative through a mixture of regulatory actions and voluntary participation schemes, implicitly avoiding to become locked into a 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 was created, the *CalFed* structure, under the twin responsibility of the Californian State and the Federal government. It supervised the so-called "three way negotiations" between farmers, urban dwellers and environmentalists (Adams and Simon, 1996). 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 labelled a landmark 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 the ways to allocate global restrictions between rightholders. 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 which had been reached. However, this initial success has been recently undermined by the recent CALFED's announcement that a formal decision about the 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[10], the procurement of water for environmental purposes has represented a significant share of the local water market activity in the Central Valley of California (Simon, 1998). 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. Most buyback programs have been funded by the federal Restoration Fund. The California Water Banks has also made standing offers to acquire water during drought years in the early 1990s.

[9] who protected the interests of Southern agribusiness (mainly fruit producers) and city districts

[10] in which the federal authorities committed themselves to substantial structural changes to the management of the federal Central Valley Project (controlling 20% of the Central Valley-Bay-Delta surface waters) in order to reduce its negative environmental impacts. In particular, it committed itself to provide firm water supplies (an additional 335 000 acre feet per year) for wildlife refuges and wetlands.

This case study shows that the impetus for the 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 for a negotiated outcome. The improvement of the Bay-Delta instream flows was obtained through a mixture of negotiations and purchase programs, with relatively little regulation involved.

The Murray-Darling river extends over four Australian States (Queensland, New South Wales, Victoria and South Australia). It is an important source of fresh water 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[11] and resulted in major ecosystem damages. Tensions have mounted not only between production-orientated activities and environmental needs, but also between different competing economic 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[12]. 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. Premiere cause de problem is lack of consistencncy beween state legislation

A series of reforms initiated in the 1970s has 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. It 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 use voluntary agreements and buyback programs, at the expense of the taxpayer . This was all the more costly that water has been consistently over-allocated in the past thirty years, 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

[11] For example, many rivers in the South have low flows in winter and spring when rain in upstream catchments is being captured in the storages; and run full to supply the irrigated regions in the summer and autumn, when flows were traditionally low.

[12] It was initially created in 1917 with a focus on the water resources of the River Murray and lower Darling. It was then enlarged in 1986 to the entire Murray-Darling catchment.

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. It also had to negotiate a compensation package to farmers in exchange for reduced water allocations by 4 to 12% to provide for environmental flows (Challen, 2001).

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 industry 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, 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 Septembre 2003). Although this decision has been welcomed by environmentalist groups[13], it is challenged by community groups[14] 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 interstate level as well as at the more local level. It is being progressively solved through negotiated agreements and compensation packages as well as massive investment (for salinity), 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 ore costly. To counteract this difficulty, a number of authors (Young and McColl, 2002; Smith, 1995) have suggested that the 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 South West of France is one of the main irrigated agricultural area in France with 138000 ha. It is of modest size 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 environmentalist groups. Moreover,

[13] The Australian Conservation Foundation said the deal was the first significant step in reversing the fortunes of the Murray Darling. « Rather than just fighting over how to make things worse for the river we're now looking at how to undo 100 years worth of damage »

[14] Murray Valley Community Action Group, 13 May 2003

the Adour river crosses several administrative jurisdictions[15] which have been enforcing different scarcity-sharing rules, leading to growing discontent and competition between water users.

In the wake of the decentralization process which was initiated in the early 80s, the 1992 water law has 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 have proved to be much more 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 consultation process than to a genuine devolution process: the State closely watches the negotiation, it defines the structure of the negotiation table; it remains the last resort decision-maker and it imposes tight constraints which restrict the boundaries of the solution space.

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, 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.

[15] The so-called « *départements* »

One could expect that this hierarchy in water right strength would translate in a hierarchy of solutions to 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.

The other common point is the uncertainty associated with the measurement of environmental needs, the society's demands and accepted trade-offs between consumptive uses and non use values. Minimum environmental allocation remains a political 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. The theoretical advantages of different voluntary settings

The preceding examples have shown that public authorities are reluctant to authoritatively implement regulations which would result in significant reduction of water entitlements or allocations without fair compensations to water users. One of the reasons lies in the difficulty to ensure that the decision is politically acceptable: stakeholders for whom water is a vital input in the production process are likely to actively oppose allocation reforms which would result in significant business losses or in a reduction of water access security, therefore increasing production and investment risks. Public agencies cannot successfully enforce water allocation rules unless they are seen as reasonable by water users.

The farming sector is a particularly sensitive group: since it is often difficult to monitor their compliance[16], it is all the more crucial to reach an acceptable compromise with agricultural producers. The fields of negotiation, conflict resolution and voluntary commitments therefore need special attention in relation to water entitlements reforms.

Three forms of voluntary commitments are analysed: devolution and negotiations; buyback programs; and contracts.

- The first one consists for the State in setting a quantitative objective in terms of water use reduction and an overall compensation package. Stakeholders are then assigned responsibility for defining management rules governing allocation of water amongst themselves. The compensation can be monetary and allocated individually but is most often offered as an indivisible prize such as the financing of new collective infrastructure or extension programs.
- Buyback programs assume that transactions take place between a state agency and right-holders selling permanently or temporarily their water licenses for a *price*

[16] Individual metering systems are not widely available in France yet, for example

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 and most often specify a given *subsidy* for a pre-defined form of renouncement to water and for a given period: fallowing the land, switching to a more water-efficient technology, adopting cropping patterns which are less water demanding etc.

The comparison between different settings for voluntary agreements will focus on three areas of expected trade-offs within the overarching objective of allocation efficiency: returns to budget, information costs and compliance.

Returns to budget is the benchmark for the efficiency of the voluntary agreement scheme: if the central planner is perfectly and costlessly informed of the cost structure of farmers, he will offer a compensation or price which just offsets the costs of foregoing water. If he is not well informed and if *information is too costly* to collect, he will probably overcompensate therefore supplying to farmers what is known as an information rent. The challenge when designing allocation and compensation mechanisms is therefore to provide incentives for truth-telling by farmers. *Acceptability* is expected to be inversely proportional to returns to budget: if the compensation scheme is insufficient, then farmers will refuse to participate or will delay the implementation of the reform program through legal action, low compliance, or other forms of protest actions. The issue is to decide what should be the trade-offs when designing the scheme in a second-best world.

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, it 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 it will offer a collective "reward"[17] which is to be paid only if stakeholders reach an agreement on a water management plan 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. The transaction costs, in terms of delays, information needs and

[17] The negotiation might also be triggered by the threat of a collective sanction. However, such framework does not pertain to the category of voluntary schemes. They imply that the threat be credible, which is rarely the case given the political economy of water management.

conflict resolution procedures are borne by the group and provide a good incentive for finding workable compromise solutions. It is also believed that when implementation is monitored by the group, compliance is better due to collective and mutual control. It is also argued by psychological and sociological studies (Syme and Nancarrow, 2001) that participatory processes and negotiations contribute to promote mutual understanding, to align misperceptions and to build collective values, therefore fostering cooperative behaviour. The expected benefits of a locally negotiated decision is therefore that accountability of stakeholders is improved and that the legitimacy of the decisions is higher, translating into easier implementation, less litigation and improved stability of the agreements (Caldart and Ashford, 1998).

However, devolution can also lead to deadlocks and unresolved conflicts, and may evolve 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 more scope for trade-offs (Shabman and Cox, 1995). It also helps if the 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 with biases and equity issues linked to the structure of the negotiation. The bargaining power of stakeholders depends largely on the negotiation setting (Simon et al, 2003): the composition of the negotiation table (who is invited, 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. Answers in the form of negotiation-support tools are rapidly developing (Shakun, 1992; Hamalainen et al, 1999).

- **Buyback programs: markets versus posted prices versus auctions**

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 could also be implemented in Australia[18]. The procurement of water for environmental purposes has represented in certain States such as California or Nevada a significant share of local water market activities (Simon, 1998). Since markets are usually thin, the most common form of transaction is bilateral negotiation (Saleh et al, 1991). Such transactions usually involve 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

[18] It has to be noted that Victoria in Australia has used auctions in 1988 to allocate new irrigation water entitlements in an attempt to direct limited water supplies to their highest value use (Simon and Anderson, 1990). The idea therefore to use he same mechanism to buyback water entitlements is defendable.

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 (Simon, 1998). 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: they have the advantage to imply lower administrative and information costs and also to be considered as "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. They usually hinder the regulating agency from acquiring water selectively according to his 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 1992 (Howitt and Vaux, 1995).

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 to be used for environmental purposes: the auction design varies but it usually involves sealed bid offers. The advantages is that the public agency does not have to acquire information about sellers and may in fact gain this information by observing the bids. Moreover, it can adjust the bid ranking procedure so as to select the offers which suit best its demain, 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[19] was held in 2001 in the Flint river basin: several hundreds of farmers participated and 33000 acres were temporarily taken out of irrigation to increase in stream environmental flows (Laury, 2002). The field trial revealed that the iterative setting was administratively costly and ended up with a final equilibrium price paid to farmers which was much higher than the average initial bids.

One of the main issues with auctions (Stoneham et al, 2002; Chan et al, 2003) is the risk of collusive behaviour by sellers, especially when they are not numerous or when they are linked through strong social networks (which is often the case when sellers are farmers) which favour communication and trust. The advantages of competition can also be jeopardized in a framework of repeated auctions, which provides sellers with past information on their competitor's values and behaviour, and on the auctioneer's reserve

[19] 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.

price (Hailu and Schilizzi, 2003). 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.

Décrire auction

- **contracts**

By signing a contract, the farmer makes a commitment to adopt environmentally-friendly practices or/and technologies for a given period in exchange for government payments: it is the case of agri-environmental schemes in Europe (such as the Countryside Stewardship in the UK or the "*Contrats Territoriaux d'Exploitation*" in France), the Environmental Quality Incentives Program in the US, and several Trust programmes in Australia. Contract[20] is a policy mechanism which is usually adopted when it is easier to monitor processes than outcomes (like in the case of non point pollution or the improvement of biodiversity). It is also a key instruments in countries where water rights are not tradable.

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 water volumes used by farmers or when water entitlement trading is not legally permitted. 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 farmers' types, the regulator can choose to design a menu of contracts (specifying a behaviour and a transfer payment for a given farmer type) which, by inducing farmers to behave truthfully and pick up the contract corresponding to their types, will minimize information rents. However the theoretical literature on optimal contract design (for a review, see Chambers, forthcoming) is based on a number of strong hypothesis which are rarely verified in reality: in particular, the regulator is expected to know the distribution of farmers' types and the cost functions of each type.

It has to be underlined that farmers are often reluctant to sell or lease their water rights on a temporary basis by fear that their rights be authoritatively 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.

3. What can we infer from a simple numerical example?

[20] The difference between auctions and contracts is blurred by the fact that contracts can be awarded competitively through auctions like in the US Conservation Reserve Program or the Australian Bush Tender trial

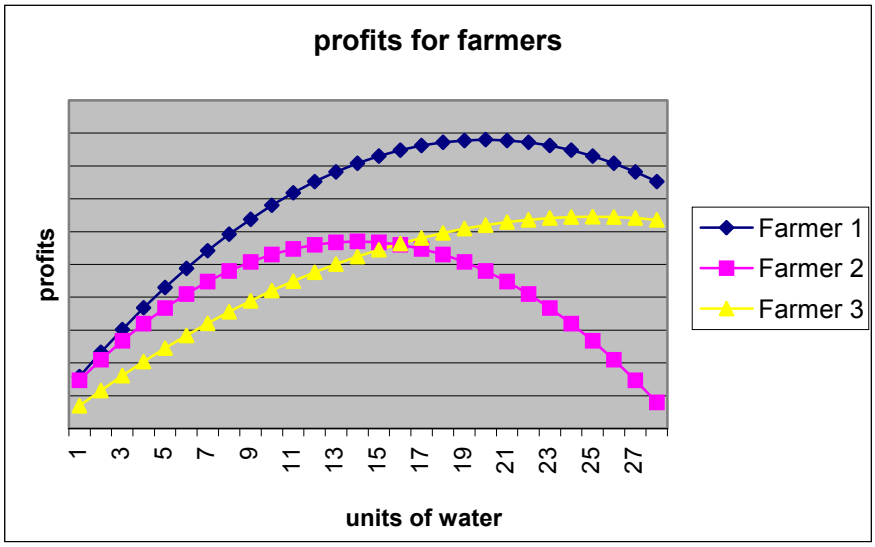
In the following numerical example, we assume three risk-neutral farmers (i = 1, 2, 3) with monotonously increasing, twice differentiable profit functions $\pi_i(D_i)$ with D_i the unrestricted use of water by farmer i. It is assumed, without loss of generality, that water is the only input.

$\pi_i(D_i) = \alpha_i + \beta_i(D_i) + \gamma_i(D_i)^2 - k(D_i)$

k is the price of water and is equal to unity

Table 1: profit function coefficients

	A	B	γ	D_i (initial entitlement)
Farmer 1	8	9	-0.2	20
Farmer 2	8	8	-0.25	14
Farmer 3	2	6	-0.1	25



The regulator wants to increase instream water flows and therefore needs to impose a total volume R of water access restrictions to the farmers. He is prepared to pay them compensations for a maximum amount of B (budget expenses have a shadow cost λ associated with the discontent of taxpayers).

The issue is to allocate $R = \sum_i r_i$ and $B = \sum_i b_i$ with r_i the water entitlement reduction and b_i the corresponding transfer payment to farmer i.

We assume in the following calculations that the farmers'utility U_i is simply additive.

$$U_i(D_i, r_i, b_i) = \pi_i(D_i - r_i) + b_i = \alpha_i + \beta_i(D_i - r_i) + \gamma_i(D_i - r_i)^2 - k(D_i - r_i) + b_i$$

Let's compare different policy mechanisms: (i) negotiation with cooperative behaviour and non cooperative behaviour, (ii) optimal contracts versus multi-unit truth-revealing auctions (iii) buybacks through posted prices and buybacks through multi-unit truth-revealing auctions.

Negotiations

Let's first make the assumption that the state wants to retrieve a total volume of R=18 and is prepared to allocate a budget B=21. Farmers are allowed to negotiate between themselves how they are willing to share the restrictions and the compensation :
$\sum_i r_i = 18$ so that $\sum_i b_i = 21$

We compare the outcomes of negotiations:

- in a Nash cooperative framework, where farmers agree to maximise their joint profits and share out equally the net gains from cooperation (*appendix 1*)
- in a non cooperative multilateral bargaining process (Adams et al, 1996; Thoyer et al, 2001) where farmers try to reap out the maximum benefit without breaking down the negotiation process (*appendix 2*)

The efficient outcome is given as a benchmark: it is the allocation of restrictions r_i which maximises the joint utilities of farmers.

We can see check that the cooperative bargaining framework leads to a Pareto- efficient outcome whereas the non cooperative outcome is Pareto inferior.

In the cooperative framework, compensations are allocated on the basis of the losses that would be induced by the default solution[21]. Farmer 3 gets the highest income transfer payment whereas in the non cooperative setting, farmer 2 gets an extremely high rent at the expense of farmer 1 who loses out. This result stems from the relative bargaining position of players 2 and 3, with player 1 having a non binding participation constraint[22] in the first round which makes him less strong in the process.

The two negotiation scenarios therefore lead to very different outcomes both in efficiency and redistribution terms. The dividing line between cooperative and non cooperative behaviour is not clear-cut in real situations. Cooperative behaviour is more likely to occur

[21] In these two simulated negotiations, the default solution (which is implemented if no agreement is reached) is identical and corresponds to an equal allocation of the restriction (minus 6 for each farmer) with no compensation.

[22] We assume that in the last round, each farmer i who is chosen to make a proposal allocates the whole compensation b_i=21 to himself (and b_j =0) and shares out equally the restrictions between his two rivals (R_j=9 and R_i=0)

when water negotiations are embedded into existing social networks which make free-riding and aggressive behaviour more costly to the community.

Table 2: comparison of the negotiation outcomes

	EFFICIENT	COOPERATIVE FRAMEWORK	NON COOPERATIVE BARGAINING
R_1	4.7	4.7	9.1
R_2	3.8	3.8	2.6
R_3	9.5	9.5	6.4
b_1	(*) 6	5.2	0
b_2	(*) 6	2.5	15.1
b_3	(*) 6	13.3	5.9
P_1	0.8	1.1	0
P_2	1.8	0.7	5.9
P_3	1.1	1.4	0.9
NIT(1)	Not relevant	0.7	-16.4
NIT(2)	Not relevant	-1.1	13.4
NIT(3)	Not relevant	4.3	1.9
Total Utility	213.4	213.4	208.4

With:

- *NIT (Net Income transfers) is the amount of compensation paid above true opportunity costs. It is equivalent to the information rent.*
- *Price is calculated as the compensation paid for one unit of water restriction*
- *(*) in the maximum efficiency scenario, all allocations of compensations are equivalent. We have selected the "egalitarian" allocation but we could have chosen any other rule.*

Contracts versus auctions

These simulations compare the solutions for only two types of farmers (farmer 1 is the high productivity type and farmer 2 is the low productivity type) when using optimally-designed contracts (see appendix 4) or multiple bid auctions (with a generalized second price payment in order to ensure that bidders are induced to bid truthfully –see appendix 3).

The simulations were conducted for a shadow cost of budget expenditures e = 1.1 and for an environmental gain associated with each unit of water saved equal to ω=2.3

We first calculated what would have been the portfolio of optimal contracts in a perfect information setting and compared it with the asymmetric information setting (see first two columns of table 3). We then used the quantity of water retrieved by the optimal contract setting with information asymmetries as a benchmark to calculate the outcomes of an auction scheme which would seek to retrieve the same quantity of water (see third column of table 3).

Theoretical results show that using contracts rather than competitive bidding results in lower average price per unit of water retrieved and lower net income transfers to farmers: Although, the regulator has to provide an excess payment to the low productivity farmer in order to induce him to choose the right contract (incentive compatibility constraint), he is successful in eliminating the informational rents paid out to the efficient farmer, although he induces him to abate less than optimally. On the other hand, auctions provide high information rents to both farmers but are more efficient since they allow a higher utility of water use and reach a greater total utility for society: the Ausubel auction design, by inducing farmers to bid truthfully, avoids the issue of averse selection and ensures the Pareto-optimality of restrictions. However, this is achieved at a higher price for the budget. This result highlights the trade-off between efficiency and returns to budget.

However, these two mechanisms 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 is the proportion 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; and incomplete since the regulator will not have information on the non participating farmers).

Table 3: comparison of contracts and competitive bidding

	CONTRACTS (with no information asymmetry)	CONTRACTS (with information asymmetry)	Equivalent-volume AUCTION
R1 R2 b1 b2	7.5 6 11.2 9	2.3 6 1.1 9.3	4.6 3.7 6.8 4.7
Total R Total B Average price (B/R)	13.5 20.25 1,5	**8.3** 10.3 1.2	**8.3** 11.6 1.4
NIT1 NIT2	0 0	0 1.6	2.6 1.3
Utility of water use (1) Total social utility (2)	124,7 153,7	134.9 153	137.3 155.2

(1) It is calculated as the sum of farming profits made by the two farmers with the quantity of water allocated to them: $\pi_1(D_1-R_1)+\pi_2(D_2-R_2)$

(2) It is calculated as: $\sum_{i=1,2}\pi_i(D_i-R_i)+(1-e)*(b_1+b_2)+\omega*(R_1+R_2)$

Buybacks: auctions versus posted prices

In this simulation, we compare the outcomes of buybacks based on posted prices and buybacks based on auctions. We have only considered the volume-constrained buybacks (or target auctions) in which the State buys back a given volume of water. Auctions are the same as in the previous section.

As expected, buyback schemes based on posted prices are less efficient than auctions (table 4): they end-up with a much higher average price paid to farmers and higher net income transfer payments. The competitive bidding process allows to substantially reduce rents paid out to farmers. However, these calculations do not take into account transaction and administrative costs, which might be very high in the case of auctions.

Table 4: Auctions versus posted prices

	Volume constraint R=18	
	Posted price (total B=34.3)	Auction (Total B= 24.6)
R_1	4.75	5.2
R_2	3.80	4.2
R_3	9.50	8.6
b_1	9.02	6.5
b_2	7.22	5.02
b_3	18.05	13.07
NIT(1)	4.51	1.09
NIT(2)	3.61	0.65
NIT(3)	9.03	4.13
Price	1.9	1.04
Total NIT	17.15	5.87

Conclusion

The three case studies show that although the water rights legal and regulatory frameworks usually allow the State to undertake compulsory takings in order to protect environmental stakes, public authorities prefer to adopt more consensual policies based on voluntary participation schemes and negotiation procedures. They are obviously more costly since they entail that compensation payments be paid out to entitlement holders but they have proved to be more politically acceptable. Selecting the best policy design is a key issue and involves measuring the potential trade-offs between the efficiency of the

allocation (maximizing the net social benefit), the total cost of acquisition efforts, transaction costs (including reluctance to comply), and the regulator's information needs.

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APPENDIX
THEORETICAL BASIS FOR THE NUMERICAL SIMULATIONS

Appendix 1: Cooperative bargaining

The Nash bargaining solution is given by:

$$Max \prod_j [\pi_j(D_j - r_j) - \pi_j(D_j) + b_j]$$

subject to $R = \sum_i r_i$ and $B = \sum_i b_i$

Appendix 2: non cooperative multilateral bargaining

Following Adams et al (1996) and Thoyer et al (2001), we model the non cooperative bargaining process as follows: this non cooperative model of multilateral bargaining is an extension of the Stahl-Rubinstein game: it incorporates multiples players and multidimensional issue spaces. The structure is the following: 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 $X^j_t = (x^j_{1,t},... ,x^j_{k,t},... ,x^j_{K,t})$ over the policy variables.

All other players i#j 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: it 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:

$$EU^i = \sum_{j=1}^{N} a_j U_i(X^j_{t+1})$$

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. It has to be noted that such game structure implies perfect information between players.

Formally, the game has no closed form solution and is solved recursively by backward induction.

Appendix 3: multiple bid auctions

Expliquer que les resultants sont tres differents.
Expliquer les differentes manieres
Impossible de calculer les differents equilibrium strategies
Choose the only method which garantees efficiency and truthful bidding: explain Ausubel

Appendix 4: Optimal contract

Following Moxey, White and Ozanne[23] (1999), we can model first best and second-best contract designs as follows:

- When perfect information, the optimal contract problem is the following:

Let's assume that we have two types of farmers, type 1 (low productivity type) and type 2 (high productivity type) with marginal costs for type 1 being consistently higher than marginal costs for type 2, and γ_i the proportion of farmer of type i, i=1,2

Compliance costs of farmer i are:
$C_i(r_i) = \pi_i(D_i) - \pi_i(D_i - r_i)$, the difference between the unconstrained and the constrained profit function

The objective function of the regulating agency is to minimise the budget costs as well as the environmental costs v associated with using a quantity (D_i-r_i) of water

$$\underset{R_i b_i}{Min}\, Z_i = \sum_i \gamma_i (b_i + v(D_i - r_i))$$

subject to the individual rationality constraint: $b_i \geq C_i(r_i)$

By writing the associated Lagrangians and the first order conditions, we find the following optimal contract (r_i^*, b_i^*) such that:

$b_i^* = C_i(r_i^*)$ and $C_i'(r_i^*) = v$

with $C_i'(r_i^*) = \left[\frac{\partial C_i(r_i)}{\partial r_i}\right]_{r_i = r_i^*}$

- With imperfect information:

[23] Moxey, A., White B. and Ozanne A., 1999, *Efficient contract design for agri-environment policy, Journal of Agricultural Economics*, Vol 50 No 2, pp 187-202

Let's assume that the regulator cannot observe the farmer types but knows the probability of each farmer type: the regulating agency needs to add an incentive compatibility constraint which ensures that farmers will select the contract which corresponds to their true types. For only two types of farmers, the second best, truth-telling contract menu must be the following.

The contract (r^*_2,b^*_2) is offered to farmer 2 (high productivity farmer) such that:

$$-\gamma_1(C_1'(r_2^*) + C_2'(r_2^*) = (1-\gamma_1)v$$

and

$$b_2^* = C_2(r_2^*)$$

The high productivity type abates less than it should but gets no information rent. The menu of contract is a second best because it achieves less in terms of water restrictions for a higher budget.

The contract (r^*_1,b^*_1) is offered to the type-1 farmer such that:

$$C_1'(r_1^*) = v$$

$$b_1^* = -C_1(r_1^*) + C_1(r_2^*) + b_2^*$$

The low productivity farmer is induced to abate optimally (like in the fist-best contract) but gets an information rent above its true compliance costs