Who gets what?
Policy lessons on how to share scarce irrigation water during droughts

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Abstract

With climate change, a number of regions in the world are forecast to face more frequent and more severe droughts, forcing the irrigated agricultural sector – often a major consumer in summer periods- to face water restrictions. One of the main challenges for policy-makers is to design mechanisms for sharing water among farmers, which can be rapidly and easily enforced, while ensuring that water is efficiently allocated without creating unnecessary inequity. Where there are no markets for water, a regulatory approach to managing demand for irrigation water is often employed – for example, irrigators are permitted to water only on certain days. However, between competitive markets and regulatory individual restrictions, there is a wide range of other solutions.

This paper examines alternative approaches to managing irrigation water in drought periods. The efficiency, effectiveness and feasibility of each instrument is considered and compared with the regulatory approach. Case studies, where examples exists, in Australia, USA, and France are briefly analysed.

The paper focuses exclusively on the policy solutions dealing with temporary, unforeseeable deficits, associated with an exceptionally dry season and low reserves. It therefore has to take into account the short-term constraints of farmers who may have to face restrictions at short notice.

Key-words : drought, efficiency, equity, policy tools, use and management rights

Introduction

With climate change, a number of regions in the world are forecast to face more frequent and more severe droughts (IPCC, 2007), forcing the irrigated agricultural sector – often a major consumer in summer periods- to face water restrictions. One of the main challenges for policy-makers is to design sharing mechanisms, which can be rapidly and easily enforced, while ensuring that water is efficiently allocated without creating unnecessary inequity. The paper focuses exclusively on the policy solutions dealing with temporary, unforeseen deficits, associated with an exceptionally dry season and low reserves. It does not describe policies seeking to reconcile long-term supply and demand trends, by encouraging water-saving choices and technologies or by increasing water reserves or alternative supply.

The type of feasible solutions depends very much on the types of water rights in place. The security of rights and the scarcity-sharing provisions are highly variable. They will define the level of risk faced by the right-holder and the relative importance of market-like versus regulatory solutions. Indeed, between competitive markets and regulatory individual restrictions, there is a wide range of other solutions which have been experienced or could be tested in the future. This paper examines the main alternative economic approaches to managing irrigation water in drought periods: flexibility mechanisms to reallocate water; risk-transfer mechanisms to reduce global risk; and global incentives or constraints. The efficiency, effectiveness and feasibility of each instrument is considered and compared with the pure regulatory approach.

The paper is structured as follows: the first section highlights risk-sharing mechanisms in water right systems and the consequent constraints faced by farmers. The second section describes water reallocation mechanisms. The third section describes risk transfer policies and the fourth section concludes.

1. Why it is difficult to define droughts and why it is needed

There is no universal definition of drought since it is a notion of “shortage”: it therefore depends on demand as well as supply. The droughts we are interested in, are temporary drought, in other words, periods of time during which the supply of water does not meet the demand in the form it is expressed through the existing water management institutions. It can therefore easily be understood that the severity of the consequences of a drought will be strongly correlated with the ability of these institutions to forecast it. What is the degree of “predictability” of a drought? The long term meteorological forecast are improving but seems to remain unable to give robust prediction on water seasonal availabilities.
Nevertheless, policy-makers need to have an indicator of drought severity in order to: provide alert; set-up sharing mechanisms; sometimes pay compensation associated with “natural disaster”.

It must be emphasized that drought differs from other natural hazards in several ways. Firstly, it is a "creeping phenomenon", making its onset and end difficult to determine. The effects of drought accumulate slowly over long periods. Secondly, the absence of a precise and universally accepted definition of drought adds to the confusion about whether or not a drought exists and, if it does, its severity. Thirdly, drought impacts are less obvious and often spread over a larger and imprecise geographical area than are damages that result from other natural hazards. Drought seldom results in structural damage. For these reasons the quantification of impacts and the provision of disaster relief is a far more difficult task for drought than it is for other natural hazards.

It is critical to note that the economic, social, and environmental impacts of drought are the product of both the natural event (i.e. meteorological drought) and the vulnerability of society to extended periods of precipitation deficiency. Expressed in another way, the impacts that result from future drought occurrences will be determined not only by the frequency and intensity of meteorological drought but also by the number of people at risk and their degree of exposure to this risk. If demand for water and other shared natural resources is increasing societal vulnerability to water supply interruptions caused by drought, then future droughts can be expected to produce greater impacts, with or without any increase in the frequency and intensity of meteorological drought.

In most cases, public authorities react to drought through the provision of relief or emergency assistance to the affected areas or sectors (i.e., crisis management approach). By following this approach, drought only receives the attention of decision makers when it is at peak levels of intensity and spatial extent and when water management options are quite limited… This reactive approach is not an efficient policy and must be replaced as often as possible by anticipatory, preventive approaches that reduce risk (i.e., risk management) through the adoption of appropriate mitigation programs and policies.

The focus on reactive approach can often be explained by the difficulty to characterise the kind of situation that should benefit of more preventive approaches. Shortage can more easily be answered by organizing the sharing of scarcity, more or less efficiently, more or less equitably, and developing future supply through management structure like reservoirs and canals. These policies that met some success in the past are now confronted to their own limits: the potential to cost effective infrastructure is now mainly exhausted. More over it is generally inappropriate –cost ineffective- for unforeseeable temporary drought that need responses in the short run, at least to avoid their most costly consequences.

The consequences are that planned activities and input expenditures do not coincide anymore with the availability of the water input: farmers end up lower on the production function and support sunk costs: revenue losses due to lower yields, lower quality of harvest , potentially market share losses or loss of contracts.

Facing a temporary drought, the reactive response consists in three main ways:

- setting up early alert systems to encourage water conservation behaviour
- implementation of use restrictions usually pre-defined in drought management plans (when they exist)
- when necessary, implementing rights to compensation

For all these purpose, an administrative definition of temporary drought is needed, and it can be observed that many States or river basin institutions have adopted an official definition of drought with a number of quantitative indicators. These definitions may sensibly differ, accordingly with the kind of issue anticipated and the type of information available.

Many policy response are implemented according to the existing legal system. When the water management rests on annual licenses: the choice is between not renewing a part of the licenses in the drought affected region, following priority schemes, and renewing all the licenses, but with a reduced quantity of water (both cases are likely to result in calls for compensation). Since the water authority is unlikely to get perfect information on the marginal values of water use, both are inefficient means of reduction. They are probably unfair since in both cases, farmer bears all costs (may be able to share if can produce something and if output prices received rise in drought).

Other regulation can be implemented:

- limit the amount of water applied per farm (for example, some percentage of the licensed amount, or some percentage of the amount used last year or average of recent years)

- limit production on farm (for example, no production on a certain number of acres)
- Impose restrictions on time of irrigation (for example, can only water in the evening, or on certain days)
- Impose restrictions based on method of irrigation (for example, only drip irrigators may irrigate)
- impose restrictions based on place of irrigation
- tie restrictions on water use to drought assistance?

Since there is information asymmetry and limited enforcement or implementation capacity, all these measure appear as inefficient means of reduction, and may result in calls for compensation. Moreover:
- Transactions costs may be high (monitoring, enforcement)
- If based on method or irrigation, will affect investment in technology (if policy is thought to be long run)
- If based on amount of water used in previous years, will be an incentives to use more water in the future

2. Scarcity-sharing mechanisms embodied in water rights

In some country, there exist currently several water right systems that involve the capacity to adapt to drought periods. According to their design they are associated with a varying level of security for their holders. A water right is an entitlement (provisory or permanent) but it does not guarantee that the resource is available since water quantities are contingent upon climate conditions and decisions of upstream users.
In the following paragraphs these systems will be briefly described and the scarcity-sharing provisions of each systems will be emphasized: from very secure/insecure (senior rights in California) to the proportional share in Australia, or the regulatory restrictions in France. It can easily be shown (see Figure 1.) that either rights lose their value or regulatory authorities need to step in to reduce rights one way or another. In such case, due to information asymmetries it is not sure at all that the restrictions will affect the lowest marginal uses.

1) Proportional rights : the Australian case

In Australia, water rights are administered on the basis of a patchwork of statutory and riparian common law. 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 (to some extend similar 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.

2) "Prior appropriation": Californian water rights

In California, 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."[1] Water rights are appropriative rights, attenuated only by three historic

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[1] The Doctrine of Prior appropriation was established to serve practical demands of nineteenth century water users in the western states of the US. It originated in the customs of miners on federal public lands who accorded the best rights to those who first used water. It was later extended to farmers and other users, including those who privately owned land. Appropriative rights were recognised under the common law of local courts. Water is considered to be a public resource and individual can claim a right to use water if they could demonstrate that water was put to beneficial use, initially defined as the

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. Actually, in each of the Western States the water right management evolved following different way to face the growing and changing demand for water use (often to divert water from agricultural use to urban use). Water right transfers may be subjected to the authorization of State engineer who will check what are the effects of the transfer on third party, following the place of diversion, the type of use, the rate of release, etc., and possibly the degree of priority of the right.

3) "Use licenses": the French case

"Use licenses" are, theoretically, delivered annually for a given discharge and a given use 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.

Finally, following the existing water rights 3 ways of sharing scarcity when:

i) proportional sharing when rights are defined as a share of available water – this is what is proposed and partially implemented in the Australian system (see Young and Mc Coll, 2003);

ii) prior appropriation system leads to give the remaining water in period of shortage to the more senior rights (the implementation varies among the different US western state, namely in California, Colorado);

iii) administrative sharing gives to the water authority the responsibility to define priority among the users that hold the licenses.

Without further development, it can easily be understood that there is a strong need for flexibility mechanisms to reduce both individual losses and collective losses: Three solutions:

- either allow water quantities to be allocated to its highest marginal value – water markets – or when not available water buybacks. When water rights are not tradable, use of shortage pricing to mimic market
- risk-transfer mechanisms to ensure that drought risk is allocated so as to minimize global risk: water options, water contracts and insurance
- collective incentives to reduce use: education, reward and sanction?

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application of water for agricultural and mining purpose, and since broaden to include household, commercial, recreational and environmental purpose.

3. Flexibility mechanisms for reallocating water rights

Three main flexibility mechanisms can be implemented to pursue efficiency improvement.

Water markets

Competitive markets are usually the most efficient mechanism to allocate scarce resources, because the confrontation of supply and demand will automatically –through the invisible hand- reallocate water to where it can yield its highest value. Water markets can be operational provided a clear, comprehensive and enforceable property right system exists and provided that transaction and regulatory costs do not outweigh the potential gains. Water markets as such do not create additional resources but they allow to re-allocate restrictions imposed by scarcity (in the case of proportional restrictions or in the case of priority rights) in a more efficient way.

Moreover, the existence of market mechanisms is expected to improve on-farm water-use decisions with regard to drought risks by turning the input rationing risk (limited amount of water leading to irreversible losses for cattle or perennial crops) into an input price risk (with greater water expenditures than expected). This last risk can be more easily accepted by farmers because savings or access to the credit market can provide acceptable coverage.

Public buybacks

Another way for public authorities to organize rationing is to organize market-like public buybacks: such public purchases can be organized through procurement auctions. It is the case of the case of the Flint River Drought Protection Act (enacted in 2001) in the Georgia state. The objective is to reduce irrigated acreage in periods of drought in order to maintain acceptable river flows. Technical water services evaluate the risk of an upcoming drought by the 1st of March of each year (looking at water stocks, permits issued, weather forecasts and statistics). If a drought is declared, then the buyback process can be initiated and has to take place within the following 25 days. It is implemented through an "auction-like" process in which farmers offer (voluntarily) to forego irrigation on all acreage covered by a given water use permit for the remainder of the calendar year in exchange for a one-time lump sum payment determined by the auction process. A given budget is set aside to compensate those farmers. Farmers can still use the land for rain-fed production.

Other equivalent mechanisms include water banks as a means of temporarily modifying water allocation procedures during water shortages. The California Drought Water Bank program is an example of an innovative and successful mitigation action (California Department of Water Resources, 1992). This program was created in 1991. It allowed the Department of Water Resources to acquire water in three ways: (1) by purchasing water from farmers who chose not to irrigate; (2) by purchasing surplus water from local water districts; and (3) by paying farmers or water districts to use ground water instead of surface water. MacDonnell et al. (1994) present a review of water banking in the West.

Variable pricing

In the short run, the total quantity of water in a water supply system and/or the system delivery capacity is generally fixed. Since volumetric pricing (charging based on the volume of water consumed) affects the quantity of water demanded, such prices could be used during periods of drought to equate demand and supply (Varela-Orega et al, 1998) .[2] Using volumetric prices to ration fixed supplies is economically efficient: water users adjust their water use until their marginal benefits equal the the marginal cost (the price of water). If

[2] A volumetric price will have no effect of the quantity of water consumed if demand in the relevant price range is already constrained; the change in price needs to be sufficiently large.

water users have no fixed allotment of water, or if they can freely trade their water allotments, this will ensure that water is distributed to users who place the highest value on the water.[3]

However, volumetric variable pricing requires that it is possible to measure the volume of water being used. Pricing structures that involve changes in price at different times or in different situations requires meters to be read at the point of change. . There are costs in providing metering infrastructure and reading meters. These costs need to be evaluated against the benefits of introducing or changing pricing arrangements.

Formulation of pricing policies to address drought requires some knowledge of the price elasticities of demand for water. Also relevant is the cross-elasticity of price with income, since the price responsiveness of demand for water depends on the income levels of water users (Howe 2005). With highly inelastic demands, a large change in price is needed to have a significant impact on quantity demanded. Because of this, using price to ration demand has often been viewed s politically unacceptable.

Ideally, with full information, pricing could mimic the sale outcomes of a perfectly functioning market. However, if there are significant threshold effects and uncertainty about being able to stay below a certain target, policy makers may prefer quantity regulations or a combination of price and quantity.

4. Risk-transfer mechanisms: Option contracts and interruptible contracts

The preceding section presented ways to allocate scarce water to its highest value use when drought is already there. We have shown that market or market-like mechanisms are theoretically the most efficient to maximize the total use value of available water. However, they come at a high cost for risk-averse users because they do not reduce overall risk. Another –potentially complementary- response to drought threat is to set-up risk-transfer mechanisms in order to reach a more efficient ex-ante sharing of hydrological risks and therefore to avoid inefficient self-insurance strategies or costly investments in water supply alternatives.

It is a fact that water users who are risk averse or with greater vulnerability to water scarcity have a greater willingness to pay for secure and reliable access to water. There is thus scope thus to transfer risks associated with water shortage from this category of users to the more risk-prone, less drought vulnerable users, in exchange for a compensation payment. The underlying idea is to set-up water option markets in which the purchaser of the option gains the right to buy a minimum quantity of water at a pre-specified price (called the striking or exercise price) over a given period from the seller of the option. The seller of the option is thus guaranteeing future delivery under specified conditions and price. In exchange, a further premium above the striking price –called the option price – is paid to the seller. This premium can be paid annually over the duration of the contract or as a lump-sum at the time of signature. Hertzler (2004) refers to this system as “exotic options” because the quantity is a random variable as opposed to price. A water option is also different from a financial option because there is no transfer of property, the entitlement is retained by option seller.

Existing literature has envisaged option contracts between the agricultural sector and municipalities to improve the reliability of urban water supply (Michelsen and Young, 1993; Gomez-Ramos and Garrido, 2004), between the agricultural sector and hydropower companies to firm up electric power production (Hamilton et al, 1989), or between irrigators and the environment to ensure minimum flows in rivers in drought period (Heaney and Hafi, 2005). In all cases described in the literature, irrigators are the sellers of water options. Empirical studies cited above demonstrate that the option value, which is the maximum

[3]Another function of water prices is provision of revenues for the water supply authority. Here, we call such ‘prices’ an administered charge, and treat this separately from prices related to water scarcity.

economic benefit of an option contract – and therefore the maximum price a purchaser would be willing to pay for the option – is often greater than alternative arrangements such as investments in water conservation strategies or in alternative supplies. Part of this option value is paid –even if the option is not exercised- to the irrigators as an incentive to enter into an option contract: it is the option payment and is negotiated between the purchaser and the seller. The remaining value is the net benefit to the holder of a water option contract. Irrigators will participate if the option value increases their expected income and/or reduces their income variability. In practice, compensation schemes often combine annual payments – to offset average expected loss - with lump sum payments in years of water supply interruption. In this way both parties can increase incomes and reduce income risks without having to anticipate fully the number and severity of droughts.

In the French context, it could be envisaged to set-up option contracts between different groups of farmers competing for the same water resource: one category of irrigators willing to accept temporary suspension of irrigation operations (ie irrigation of pastures or low value annual crops) could sell “water-access” options to another category of irrigators with perennial or high value drought-prone crops. The “water-access” option would be a commitment to accept a greater share of the restrictions imposed by administrative authorities in case of drought. It would allow the second group to increase the reliability of their supply at a pre-arranged costs that may be preferred over other alternatives (invest in more storage capacity, dig wells, change cropping patterns).

Another comparable solution is the signature of interruptible contracts –similar to electricity supply contracts - between water users and water supply facilities. The “price of the option” in this case is the price discount that the water supplier will offer to the water consumer in exchange for the right to interrupt water delivery under pre-specified circumstances. Such contracts could be established between urban water services and some households –such as the owners of holiday houses who could then decide not to inhabit their houses during the interruption period -, or between a reservoir dam operator and irrigators downstream.

Conclusion

While a regulatory approach, depending on its design, can offer advantages in terms of low administrative transactions costs, it provides the least flexibility to farmers and hence reduces economic efficiency. Pricing approaches requires ability to measure volume or water used. Increased charges for water will have no impact on quantity of water used if demand in the relevant price range is already constrained; in other words, the price needs to be sufficiently large which may limit the political feasibility of this approach. Market or market-like mechanisms (such as buyback auctions) will allow to improve the efficiency of the allocation of scarce water by improving the revelation of the true willingness to pay of water users. However, design of such programs is important and direct costs to governments can be high. An options contract written against irrigator’s seasonal allocations of water could reduce water used at a significantly lower cost than purchasing entitlements. Moreover, by retaining their entitlements, irrigators have a hedge against the risk of decreased water availability in the future.

Table 1. Synthesis

Instrument	Design issues	Cost efficacy	Efficiency	Transaction and administrative costs	Limitations
Embedded scarcity sharing in water rights					
Administrative	Decide when to impose restrictions	No costs	Very low because no guarantee that water is allocated to most efficient use	Low – designed to minimize control costs	
Seniority	Decide on priority rights	No costs	Low if senior rights held by low marginal value users	Low	
Proportional	Decide on the quantity of available water to be shared	No costs	Good		
Flexibility mechanisms					
Through existing markets	Need for strong transferable water rights	No costs	High provided markets are reasonably competitive	Can be limited with good information system on price	Restrictions on trade imposed to limit third party externalities
Through auction-like processes	Need for transferable water rights	It depends on the auction payment rule: information rents paid to bidders can be high	Efficiency is high provided that the payment rule induces close-to-sincere bidding	Potentially high to explain the auction rules and to set-up the auction	Issue of lumpy bids
Through scarcity pricing	Need to calculate scarcity price and make it vary to reflect present scarcity –need to have continuous metering	Revenue generated by pricing – increase in revenue depends on price elasticity of demand	High if scarcity and elasticities are rightly anticipated	Potentially high due to complex invoicing	Threshold effects due to price increments
Risk-sharing mechanisms					
Option contracts	Set-up proper enforcement mechanisms – Calculation of option price in the absence of markets	No costs	High	Potentially high to agree on all dimensions of the contract (renegotiation, price adjustment etc.)	

References

Cummings R.G., Holt C.A. and Laury S.K., 2002. Using laboratory experiments for policy making: an example from the Georgia irrigation reduction auction. Working paper Georgia State University, 46 pages.

Cummings R.G., Norton N.A. and Norton V. J., 2001. Enhancing In-stream Flows in the Flint River Basin: does Georgia have sufficient policy tools? Water Policy Working Paper 2001-002, Georgia State University, 25 pages.

Gomez Ramos A. and Garrido A., 2004. "Formal risk-transfer mechanisms for allocating uncertain water resources: the case of option contracts", *Water Resource Research 40*, 1-11.

Hamilton J., Whisttley N. and Halverson, P., 1989. Interruptible water markets in the Pacific NorthWest, *American Journal of Agricultural Economics* 71 (February), 63-75.

Hertzler G., 2004. "Weather derivatives and yield index insurance as exotic options", *48th Conference of the Australian Agricultural and Resource Economics Society*, Melbourne, February, 14 pages.

Howe C.W., 2005. The functions, impacts and effectiveness of water pricing: Evidence from the United States and Canada.. *World Resources Development 21* (1), 43-53.

Johannsson R. C, Tsur Y., Roe T.L., Doukkali R. and Dinar A., 2002. Pricing irrigation water, a review of theory and practice. *Water Policy 4*, 173-199.

Michelsen A. and Young R., 1993. Optioning agricultural rights for urban water supplies during drought" *American Journal of Agricultural Economics 75* (4), 1010-1020.

Productivity Commission, 2003. *Water Rights Arrangement in Australia and Overseas*. Commission Research paper, Melbourne, Australia, 331 pages.

Productivity Commission, 2006. *Rural Water Use and the Environment: The Role of Market Mechanisms*. Research Report, Melbourne, Australia, August, 313 pages.

Varela-Ortega C., Sumpsi J., Garrido A., Blanco M., Iglesias E., 1998. Water pricing policies, public decision making and farmers' response: implications for water policy, *Agricultural Economics* 19 (1), 193-202.

Wilhite D.A., 1997. Improving Drought Management in the West: The Role of Mitigation and Preparedness. National Drought Mitigation Center, University of Nebraska, report to the Western Water Policy Review Advisory Commission, January 8.

Young M.D. and Mc Coll J.C., 2003. Robust reform: the case for a new water entitlement system for Australia, *The Australian Economic Review 36* (2), 225-234.