FRACTIONAL WATER ALLOCATION AND CAPACITY SHARING/WATER BANKING

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Abstract

In this paper, it is contended that the institutional arrangements and business models for water allocation, licensing and management have an overriding impact on how efficiently and effectively water is used in irrigated agriculture. Traditional methods for allocating and managing water are often based on volume per unit time water allocations, issued at some estimated level of assurance and managed using priority-based reservoir and river operating rules. This traditional approach is shown to have significant disadvantages in terms of ease of management, equitability and potential for fomenting conflicts. It also provides little opportunity for stakeholders to manage their water supply status and so have a positive incentive to use water efficiently. In contrast, fractional allocation and capacity sharing (FWACS) or water banking, which has been successfully implemented in the Mazowe catchment in Zimbabwe, is shown to enable more efficient, equitable and productive water use and management. FWACS is also reported to be a feasible and transparent management option for managing the reserve.

Keywords: water allocation, hydrological modelling, capacity sharing, water use efficiency, irrigation

Introduction

The institutional arrangements for water allocation and management which develop in response to the South African National Water Act of 1998 (NWA) are likely to have a significant impact on how productively water is used, especially in the irrigated agricultural sector. Since approximately 60 % of the available water resources are assigned to irrigated agriculture (NWRS, 2003), facilitating gains in efficiency in this sector is a vital strategic issue in South Africa.

Institutional arrangements which provide positive incentives to use water more effectively are likely to be key to the successful uptake and implementation of best water management practices. Widespread adoption of these best practices should, in turn, lead to higher productivity, increased and sustained profits, and a healthy environment both now and in the future. Institutional arrangements also need to be developed to cope with the increased *interdependency* of upstream and downstream users, and the associated potential for conflicts.

In order to institute positive incentives for water conservation and demand management (WCDM) and reduce the potential for conflicts, traditional water resources planning and management philosophies may need to undergo a paradigm change. In the context of the NWA, the aim of this paper is to contrast the traditional approach to water allocation/licensing and management, with a proposed better alternative.

Water allocation options

The NWA requires every Catchment Management Agency (CMA) to develop a Catchment Management Strategy (CMS). The CMS must, among other things, set principles for allocating water. The CMS should be in harmony with the National Water Resource Strategy (NWRS) and needs to be developed with stakeholder participation/approval.

Within a CMS, there are at least two contrasting options by which water allocations can be instituted by the CMA, *viz*:

- volume per unit time water allocations, issued at an estimated level of assurance
- fractional water allocations and capacity sharing (FWACS).

Volumetric water allocations and priority-based reservoir and river operating rules (VWA-PRROR)

Traditionally, water in South Africa has been allocated in terms of volume per unit time (often based on land areas) at some assumed level of assurance. For example, an irrigation water allocation of 10 000 m^3/ha/annum expected to be available, say, eight years out of 10. In times of shortages, priority-based reservoir and river operating rules (PRROR) are used by the water management authority to determine who has priority of access to the water and who should yield, and by how much. Because licenses are based on a volume entitlement, upstream users may, on occasion, pump a river dry in low flow periods even although the amount pumped may be less than their licence entitlements, thereby causing serious conflicts and problems for downstream users and the CMA. Apart from the potential for recurrent conflicts, the major problem with VWA-PRROR, is that *there is little, if any, incentive for individual water use sectors to implement effective water conservation and demand management strategies*. This is because with VWA-PRROR individual users have very limited or no control as to when in the future their water abstractions may be curtailed. Therefore, while water is available, the motivation is for users to abstract it. Also, if a user's water is stored in a shared multi-purpose reservoir, there is the risk that any water savings made by an individual and 'left' (stored) in the storage reservoir, may, at a later stage, be ceded to another user deemed to have a higher priority of use, even if this previously saved or unused water had been paid for. The outcome of the 'use it or lose it' mindset which becomes inherent in such a system is that, with the diminished incentive to save water, the number and duration of water shortage periods is likely to increase and overall water use productivity is likely to decrease.

An example of the potentially catastrophic results such an allocation and licensing option has had, happened in the Runde river catchment in Zimbabwe. Between 1980 and 1992 the available water reserves in the Runde catchment were severely depleted culminating, *inter alia*, in the near collapse of the country's sugar industry. The VWA-PRROR institutional arrangements and water allocation system which, during the 12 years preceding 1992, led many users to take as much water as they could, when it was available, played a major role in this catastrophe (in the author's opinion and based on personal communication with stakeholders in the catchment).

Despite these potential problems, VWA-PRROR are what most water users, consultants and administrators are familiar with. Also, most of the water planning and allocation decision support tools, for example, the Water Resources Yield Model (WRYM) and Water Resources Planning Model (WRPM) are based on VWA-PRROR (Görgens *et al*., 2002).

Fractional water allocations and capacity sharing/water banking (FWACS)

Under a FWACS allocation and water management system, water allocations/licences do not reflect a volume, but rather entitlement to a percentage or fraction of the total available river flow. The rate at which water can be abstracted for use or storage by any given user, is then dependent on the flow in a defined river section at any given time multiplied by the licensed allocation fraction. The weekly or monthly volumes available for potential abstraction will vary significantly with the climate of the season. If there are storage works, the total potential storage capacity is divided and portions of the total available storage made available for rental or purchase by individual stakeholders. Over time, stakeholders may decide to purchase or rent smaller or larger capacities, dependent on individual risk aversions and the willingness of other users to trade storage space.

The practical challenge of measuring and monitoring flows and water abstractions, and successfully implementing FWACS was achieved in practice, in the Mazowe catchment in Zimbabwe (Darby Doertenbach, 1998). In 1984, 11 commercial farmers formed Zimbabwe's first 'Combined Irrigation Scheme' (CIS). Each of the CIS members subscribed to a defined percentage of the cost of construction of a dam and its related infrastructure, and members further agreed that each of them would be entitled to the same defined percentage or 'fraction' of the annual new storage capacity of the dam to which the CIS was entitled. This practice allowed members to manage their own percentage share of the stored water and manage their own risk (of failure of supply) independently. However, a management system was needed to ensure its success.

"The solution turned out to be much simpler than believed possible," said Darby Doertenbach (1998). "The water in the reservoir was treated like money in a bank. Each of the participants was given a separate 'account', with a facility for both 'deposits' and 'withdrawals'. The new water to which the parent Water Right was entitled each month was quantified, separated into the appropriate percentages or 'fractions' and 'deposited' into each individual account."

Darby Doertenbach (1998) explained that the 'normal river flow' coming into the reservoir was also quantified and 'deposited' into the account of the river itself, or 'the system' as it was called. Flow measuring devices were installed at each pump and canal offtake so that 'withdrawals' could be accurately measured and debited to each account. Monthly evaporation losses were calculated and debited to each account in proportion to the account holder's percentage of total storage in the reservoir that month. At the end of each month, the reservoir's 'assets' were reconciled in the same manner as the accounts in a bank, to confirm that the total of all accounts matched the amount of water in the reservoir. 'Bank statements' were produced monthly for each account, showing deposits, withdrawals and a month-end balance. These calculations, while difficult to manage manually, were easy, quick and accurate to make when computers and spreadsheets became readily available.

The same management methods were applied to water that was released from the reservoir. This water was a mixture of natural river flow (which belonged to 'the system' account) and stored water released for transmission to account holders downstream. The amount of water released (deposited) into the river was measured, as was the amount abstracted (withdrawn) by all those abstracting water downstream of the reservoir. Darby Doertenbach (1998) noted, "Not all downstream abstractors were members of the CIS and both members and non-members also had Rights to river flow (or system water) which was 'passed through' the reservoir." At a point downstream of the last CIS participant, the amount of water flowing downstream was also measured. The section of river between the dam and the downstream measuring weir was then 'reconciled' in the same manner as the reservoir.

Each month, the reconciliation of the river section between the dam and the downstream measuring weir produced a significant 'surplus' or a small 'loss'. The surplus in the downstream river section was assumed to be a combination of irrigation return flow and natural river accretions, and was called 'generation'. 'Gains' and 'losses' in the reservoir itself were assumed to be due to normal inconsistencies in the 'smoothed' surface area/capacity curves for the reservoir and/or natural 'generation' from the section of the river submerged by the reservoir. In order to prevent the possibility of prejudice to other Right holders, the 'generation' in both the reservoir and the section of river below the reservoir was quantified and deposited into the account of the 'system' so it could be 'withdrawn' by those with Rights to river flow.

"The new management system received broad approval from both the CIS members and non-member Right holders," says Darby Doertenbach (1998). "It was simple to calculate, easy to understand, mathematically verifiable, and transparent. Released storage could be mixed with natural river flow and safely transported downstream without suspicion or prejudice. Natural river flow was quantified more accurately than ever before and readily available to those with Rights to river flow." The management system also satisfied the original requirements of the CIS participants, all of whom were free to manage their own stored water and risk of failure as their individual financial circumstances required, just as if they were owners of individual private reservoirs.

Apart from being implemented in practice successfully, FWACS has also been:

- assessed in terms of equity and efficiency by Natsa *et al*. (2000)
- assessed in terms of environmental water releases by Symphorian *et al*. (2002)
- the principles underlying FWACS have been reported on in an Australian context by Dudley and Musgrave (1988) and Dudley (1990).

The main advantages of FWACS include:

- It is relatively easy to audit and regulate water use because the rate (and hence the weekly, monthly or annual volume) which individual users are allowed to abstract at any given time can be determined from actual flow measurements and reconciliation. Whilst presenting some practical implementation challenges, flow measurement and monitoring is a non-negotiable requirement if water is to be managed equitably - under any system.
- the licence conditions allow upstream and downstream users to be managed in an integrated fashion, as opposed to a licence based on a volume entitlement which may result in upstream users pumping a river dry in low flow periods, even though the amount pumped may be less than their licence entitlements, thereby causing serious conflicts and problems for downstream users and the WMA.
- It is a more equitable option. Periods of high or low flows affect all users in a predictable, equal fashion.
- Most importantly, users are empowered to manage their water supply status/security, and can receive direct benefits from any water savings they make.

There is, therefore, a positive incentive to institute WCDM strategies. There is also a framework to facilitate 'win-win' water trades. The associated transfer of water to more productive users can therefore take place transparently and with minimal administrative complications. In addition, optimising strategies such as deficit irrigation (English, 1990; Lecler, 1999) will be facilitated. The overall result should be a significant improvement in the productive use of water and few conflicts. Individual stakeholders will be confident that water savings resulting from investments can be stored and saved for use (or trade) at a later stage, for example during droughts, rather than taken and possibly wasted in high rainfall seasons. This is a key aspect of FWACS, the significance of which should not be underestimated (Lecler, 2003).

Discussion and conclusions

In order to be sustainable, irrigated agriculture needs to make more efficient and effective use of available water. Availability of appropriate technologies and tools for field level WCDM, such as improved hardware, system designs, automatic weather stations and irrigation scheduling guidelines, is, however, only part of the solution. Appropriate institutional arrangements must be developed and implemented to provide the incentives needed to encourage adoption and implementation of these WCDM methods and tools, and ensure that individual farmers can benefit from such adoption. Arrangements which provide positive incentives to use water more effectively are likely to be key to the successful uptake and implementation of Best Irrigation Management Practices. In this regard, it was shown that traditional volumetric per unit time water allocations, issued at some estimated level of assurance and managed using priority-based reservoir and river operating rules have significant disadvantages in terms of ease of management, equitability and potential for fomenting conflicts. Critically, they also provide little opportunity for stakeholders to manage their water supply status and so have a positive incentive to use water efficiently. In contrast, fractional water allocation and capacity sharing (FWACS), which was successfully implemented in the Mazowe catchment in Zimbabwe (prior to the present chaos and turmoil in the farming sector there), was presented and shown to enable more efficient, equitable and productive water use and management.

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