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OPPORTUNISTIC BEHAVIOUR BY PRIVATE IRRIGATORS WITHIN A CAPACITY-SHARING REGIME

WJ de Lange¹ and N Vink²

Abstract

The concept of capacity-sharing (as a specific type of demand-orientated water management strategy) is a relatively newcomer on the South African water management regime and much debate is currently under way regarding the viability of the concept for the South African context. One of the main features is that it decentralises and integrates water management to a much greater degree than state-dominated management regimes. However, as the concept of capacity-sharing allows a greater degree of decision-making autonomy to the private decision-maker, the question could be asked to what extent the management of a capacity-sharing regime would be exposed to opportunistic behaviour from private irrigators. If it is heavily exposed, there are considerable scope for opportunistic decision-making behaviour under private decision-makers and therefore problems of moral hazard / adverse selection and rent seeking could present itself. Therefore, the question arises what safety features do capacity sharing present to confine possible opportunistic decision-making practices. This article discusses two areas within a capacity-sharing regime that are likely to be exposed to opportunistic decision-making behaviour. Possible safety-features from capacity sharing to account for this type of behaviour are identified and discussed briefly. This article concludes with the notion that capacity sharing does feature some properties that could minimise opportunistic behaviour from private decision-makers.

1. THE CONCEPT OF CAPACITY-SHARING

The bulk of current literature and research on the practical implementation of capacity sharing has been conducted in Australia by Norman Dudley (Dudley, 1988a; 1988b; 1990a; 1990b; 1992; 1994; 1999; Dudley & Musgrave, 1988; Dudley & Bryant, 1995).

¹ Masters student at the Department of Agricultural Economics, Faculty of Agricultural and Forestry Sciences, Stellenbosch University.

² Chairperson and Professor at the Department of Agricultural Economics, Faculty of Agricultural and Forestry Sciences, Stellenbosch University.

Within the South African context, capacity sharing has been dealt with at an institutional level (Gakpo & Du Plessis, 2001 and Gakpo *et al*, 2001) and some comparisons have been made between mathematical programming techniques that are used in the implementation of the concept (Viljoen *et al*, 2000:1).

A theoretical framework and model of the concept of capacity sharing have been suggested by Dudley (1988a:633-640 and 1988b:641-648) and Dudley & Musgrave (1988:649-658). Updated versions of the articles in 1988 are to be found in Dudley & Bryant (1995) and further readings on the concept of "capacity-sharing" could be found in Dudley (1990a:381-402; 1990b; 1992:757-778 and 1994). Although several problem areas have been identified, the work of Dudley can be used as a point of departure to test the concept of capacity sharing within the South African context.

1.1 Capacity-sharing defined

A common approach to the management of publicly owned water resources for irrigation purposes is to allocate either the current reservoir contents or potential reservoir volume of regulated flow. Capacity sharing is different in the sense that it is an **integrated, demand-oriented water management strategy that focuses on the interaction and communication between water users and managers of water reservoirs or storage capacities** (Dudley & Musgrave, 1988:649).

Major questions to be answered include:

- (1) How reservoir releases should be managed through time, (this question includes aspects like the way weather dependent fluctuations in irrigation water demand should be incorporated into release strategies);
- (2) How best the probabilities of such releases can be summarised and communicated to users; and
- (3) How users could be assisted to make the best use of such information. The basic procedure develops a computer model of a simplified river irrigation system and uses this model to answer the above-mentioned questions. This simplified system makes use of inflow, evaporation and capacity characteristics of the specified storage capacity and climatic data of the cultivation area, for the modelling.

The concept of capacity-sharing divides the single large reservoir into many “compartments” or “sub-reservoirs”, each controlled by a single decision-maker who controls releases from the sub-reservoir and makes farm management decisions. The management of the whole reservoir is reduced to the monitoring of the individual releases by water users. Thus, the model is essentially an aggregation of the many small, single decision-maker models that are scaled-down versions of the single decision-maker approach as mentioned in Dudley, 1988a.

Each user is allocated a percentage share of the reservoir’s total capacity and a percentage of the net reservoir inflows (in the form of water use rights)³. These percentage shares would not need to be equal across users, nor would the percentage shares of inflow and capacity allocated to a specific user necessarily be equal (Dudley & Musgrave, 1988:650).

Dudley & Musgrave (1988:650) illustrate the fundamentals of capacity-sharing as follows:

“To illustrate the fundamentals of reservoir capacity-sharing as envisaged in the paper, first assume that the single reservoir in question is cube shaped. Imagine that vertical water tight partitions are inserted in this cube, two parallel to the east-west sides and two parallel to the north-south sides, dividing the cube into nine equal-size cells. Thus the plan or birds-eye view of the reservoir would show nine equal-sized squares. Each of the users would be allocated exclusive use of the cell, able to withdraw water from it over time as wished, and each receiving an equal share (one ninth) of net inflows to the reservoir unless the relevant cell was too full to take the their net inflow share. In the latter case the inflow in excess of that required to fill the cell would be lost to that use.” (Note that there will be periodically adjustments of spilled inflows where the user will regain some of the lost inflow.)

“Refer to the contents of each user’s cell as that user’s inventory. It would be necessary to monitor each user’s inventory through time in a real-world application of capacity sharing because the imaginary partitions introduced above would not exist. Thus, the operations of the reservoir could be likened to those of a money bank where each depositors’ money is not kept in a separate physical location to monitor accurately the amount, which that depositor has in

³ Net inflow is defined as the inflow within a specific time period minus the evaporation and seepage losses (Dudley & Musgrave, 1988:650). Note that the water use right (that was bought) on inflow shares reserves only the right to buy these shares, the shareholder must still pay for the volume of water he wish to obtain.

the bank. Instead, the homogeneous money is intermixed and the monitoring performed by keeping tally of each depositor's withdrawals, deposits, interest charges, etc. Similarly, each users' inventory within the reservoir would be monitored by tallying withdrawals and net inflows."

It is useful to continue this analogy by noting that the reservoir capacity shareholder is like a bank depositor who cannot incur a negative balance, cannot accumulate deposits in excess of a maximum (which is a percentage of the maximum sum of deposits which the bank can hold) and cannot control the amount or timing of deposits. Instead, deposits (inflows) are made according to a stochastic process with a probability distribution, which is known to the capacity shareholder. However, beyond these stochastic deposits (inflows), which are made independently of the actions of other shareholders, there may be extra deposits made periodically to a depositor's (shareholder's) account (capacity share) because of the heterogeneous behaviour of all shareholders (periodic adjustments because of spill over effects and trading).

If there is no guarantee that the reservoir will be full at the start of the irrigation season (in other words assuming a stochastic supply), a user with a more secure title to a capacity share might behave risk-aversely by developing only a small area of land for irrigation purposes (one that can be irrigated across years with a high degree of reliability). Alternatively, a user might develop a large area, knowing that irrigated production from it will fluctuate from year to year. In this case, it seems that the greater degree of security of tenure offered by the capacity share, which includes the net inflow, would allow for more effective long-term investment decisions and short-term water transfers.

1.2 Advantages of capacity-sharing

According to Dudley & Bryant (1995) the main advantages of capacity sharing include:

- Clearly specified water use rights to percentage shares of stream-flows and reservoir capacity. (Therefore creating a more transparent water right.)
- The shares can apply to all user groups including irrigators, urban residential, environmental and industrial uses. (This reflects on the flexibility of the concept.)
- The supply of water into the reservoir is known or determinable from historic stream flow data. It is not affected by policy and institutional rules and therefore enables the user to make use of modern production and financial aids provided by consultants.

- Capacity sharing enables users to plan ahead to a much greater degree because of the smaller amount of uncertainty involved.
- Computer simulation programmes are available to aid irrigators to integrate supply and demand decisions.
- Capacity sharing promotes the decentralisation and integration of supply- and demand-management for both the short-term operational decisions and the long-term investment decisions. The integration of demand- and supply-management by shareholders enables irrigators to determine their reliability requirements and therefore save on transaction costs.
- Individual users may manage their shares with no interference from other users, unless they violate the operating rules of the system. They may or may not choose to interact with other users through participation in water markets when it is advantageous to do so. (Physical constraints in the delivering system may sometimes limit the extent of involvement of other users.)
- Capacity sharing allows water marketing to convey the current opportunity costs of water, eliminating the need for centralised pricing.

What makes capacity-sharing appealing (according to Dudley & Musgrave, 1988:651) is that it allows the probability of water supply for a user to be defined to a large extent independent of intra- and inter-seasonal carry-over policies of reservoir management as well as independent of the quantities and timing of the usage demands of other users through time. Therefore, each user can, to a greater extent, achieve his desired reliability of water supply, independent from others. This greater control over storage capacity in the long run should assist a user in considering the full opportunity cost of stored water in his capacity share. If market transfers of such capacity shares were possible or be allowed, the efficiency of water usage should further increase.

A capacity shareholder would be able to use the reservoir volume at the beginning of the season as well as the probabilities of stream flow and evaporation, to determine the probabilities of various quantities of water being available through the season, depending on his own water use pattern. Therefore, a user under a capacity share system has a greater sense of *security* via a more *clearly defined right* and would require less information (reducing transaction costs) for decision-making. Capacity shares, therefore, provide a more secure basis for the transfer of water between users than the probabilities of water becoming available conditional to early season use patterns as in the case of volume sharing (Dudley & Musgrave, 1988:651).

Users with capacity shares would be able to predict their future water supplies more accurately and therefore be able to determine with greater certainty the quantities of water they wished to buy or sell. This last point makes capacity sharing an ideal point of departure for the introduction of water markets in the given catchment.

Capacity sharing therefore integrates and coordinate supply and demand management decisions which will assist decentralised water management. This is in line with the current devolution of water management and its infrastructure to catchment management agencies and water user associations.

The applicability of capacity sharing in the current South African water institutional context may seem to be limited⁴, because of the few successfully transformed water user associations in South Africa. As more and more water user associations are successfully transformed from previous water management institutions (like irrigation boards) and as the introduction of market based water allocation mechanisms gains support, there should develop a need for research on the applicability of capacity sharing within the water user association, especially if efficiency gains became an issue.

2. OPPORTUNISTIC BEHAVIOUR IN CAPACITY-SHARING

The remainder of the article will discuss two areas of possible opportunistic behaviour from private irrigators under a capacity-sharing regime and some safety features that could limit (although not eliminate) these problems.

The problems of adverse selection/moral hazard⁵ and rent seeking⁶ are related because all of them thrive on asymmetrical information and will

⁴ Restricted to within a given water user association.

⁵ Adverse selection is defined by Lipsey & Gaurant, (1996:369) as the tendency of people who are most at risk to buy the most insurance. This problem is closely related to the problem of moral hazard where one party of a transaction has the ability and incentive to impose costs on the other party (Lipsey & Gaurant, 1996:368). Both the problems of adverse selection and moral hazard could arise when privately held information is bought and sold.

⁶ Rent-seeking behaviour could be defined as behaviour whereby private decision makers try to use the powers of the state to enhance their own economic well being (Lipsey & Gaurant, 1996:377). Within the context of capacity-sharing, rent-seeking behaviour could be found when private decision makers use the power of the state to either subsidise their water, keep their water prices at artificially low levels or promote the development of new water supplies by ignoring negative social and ecological externalities.

encourage opportunistic behaviour at private decision makers because of the differences in marginal private costs/benefits and social costs/benefits associated with these problems. These differences lead to inefficiencies and sub-optimal distributions of resources.

2.1 Opportunistic behaviour in the general management and operation of a capacity-sharing regime

Some concern may be present regarding to what extent private irrigation management (with regard to periodic adjustments of spill-over gains and evaporation losses) decisions influence or determine reservoir management decision-making. If it is heavily depended, there is considerable scope for opportunistic decision-making behaviour under private decision-makers and therefore a problem of moral hazard/adverse selection could present itself. Therefore, the question arises what safety features do capacity sharing present to confine possible opportunistic decision-making practices. An example of such opportunistic behaviour in capacity sharing is the practice of buying (or renting) all additional unused storage capacity a private decision-maker could find. The rationale behind this behaviour is seated in the rule that any inflows exceeding the unfilled space of a shareholder's capacity share will be lost to that user and being shared among others whose share is not yet full. The opportunistic private decision-maker with ample unused storage capacity will therefore receive a windfall gain each time another user (who is likely to be considerable more risk averse) caused an internal spill. (The more unused storage capacity the decision-maker owns, the more windfall gains will be received). In this way, the opportunistic decision-maker could minimise his inflow shares and therefore save considerable on buying irrigation water (cost saving therefore prove to be the underlined motive for this type of opportunistic behaviour).

However, such opportunistic behaviour of gaining on internal spills, are unlikely to occur in practice since the individual shareholder would sell some inflow shares before the loss of an internal spill could realised. In the case of spilling of the whole reservoir, no trading would be necessary since all capacity shares are filled and spilled. The water "lost" in such an event will be of little value to anyone within the reservoir, because it cannot be stored and therefore the opportunity cost not preserved.

Another argument against the above-mentioned problem of opportunistic private decision-making could be based on the natural supply-characteristics of the area in which the reservoir is located. Capacity sharing is especially suitable for areas with stochastic water supply characteristics. A great degree

of uncertainty regarding the inflow probabilities are associated with this type of supply and therefore creates an incentive to keep an adequate stock of water at all times. This will certainly not enhance opportunistic decision-making, but it will also not restrict such behaviour.

Another argument against the problem of opportunistic private decision-making focuses on the management hierarchy of the capacity-sharing system. Reservoir management does not deal directly with small private decision-makers, but with "bulk"⁷ capacity shareholders unless the private decision-maker is of a similar size as the "bulk" shareholder. Opportunistic decision-making is based on incentives for private gain in order to enhance efficiency (cost saving or greater profits). "Bulk" capacity shareholders do not have the same high level of incentives for enhancing efficiency (and therefore opportunistic decision-making) and since the private decision-maker deals more with the "bulk" capacity shareholder, the reservoir management is not exposed to opportunistic decision-making to the same degree as the "bulk" capacity shareholder (refer to Dudley & Bryant, 1995:8).

2.2 Opportunistic behaviour under capacity expansion of the reservoir

The second possible area where private opportunistic decision-making could be problematic could be found at the expansion of reservoir capacity should it prove to be necessary. Although strictly a supply-driven argument, it is appropriate to mention it here because of the interaction with demand management and capacity sharing.

According to Dudley & Bryant (1995) the best time to increase the capacity of the reservoir or to build new reservoirs would be when the aggregate value of bids for the shares for the new storage capacity plus a government subsidy equals the construction costs.

The question could be asked whether this could lead to rent-seeking behaviour. There will always be incentives for rent-seeking behaviour within a democratic and capitalistic regime and it would be naïve to try to neutralise all incentives for rent-seeking behaviour. In this case, a more realistic argument could be based on the ability of capacity sharing to withstand rent-seeking behaviour. The concept of capacity sharing hinders private rent-seeking behaviour because water management is more transparent under this

⁷ Scott & Coustalin (1995:968) refer to "trusts" and could be seen as similar to "bulk" capacity shares.

strategy. All water users have lobbying power through Water User Associations and because of the water market mechanism and sometimes-contradictive water use patterns, water users will monitor each other. If the state decides to give way to one particular rent-seeker, other rent seekers could make a strong argument against the viability of the decision based on measurement-related problems associated with the quantification and balancing (prioritising) of potential gains for the favourable group against the potential social and environmental costs of the decision. This implies the quantification of the opportunity cost of water that proves to be a controversial topic. The argument will end in a moral hazard because of the insufficient measurement of decision-making criteria and the decision will be made in the interest of the party with the biggest lobbying power. However, given the firm objectives for sustainable development and an efficient but equitable water allocation as mentioned in the National Water Act of 1998, to would be difficult to imagine that the state would be interest in private rent-seeking behaviour unless bureaucratic self-interest has the final decision-making authority.

A second argument against rent-seeking behaviour within a capacity-sharing regime could be based on the definition of water use rights. Given that rent-seekers exercise their lobbying power for an increase in supply, it should be noted that private decision-makers are only allowed the volume as specified in their water use rights. If the user needs more water, the additional water use rights must first be obtained before the extra water could be bought. The definition of water use rights will therefore play an important role in the prevention of rent-seeking behaviour.

The inherent "common property" and variable nature of river flows complicates the definition of property rights to water. This variability in supply (stochastic supply) complicates water balances (by creating uncertainties regarding supply probabilities) within a catchment and it is therefore common practice to use dams or other forms of storage capacities to regulate and smooth out the supply of water from year to year. However, these storage capacities do come at a price and it is a complex task to determine the exact magnitude of such practices. Suitable storage management strategies and policies have to be developed to cope with this situation. The work of Dudley, 1988a; 1988b; 1990a; 1992; 1994; 1999 and Dudley & Musgrave, 1988) deals extensively with this type of problem. The definition of tradable water use rights must therefore be compatible with the management of storage capacities. In defining water rights for the purpose of accommodation within a market, the emphasis should be on the use right of a specific unit of water and not on the property right of that unit of water,

because the utility of water is derived from the use right and not the property right. Therefore, the characteristics of the water use right should play the dominant role in defining water rights for adoption in the market. The question could be asked whether water use rights will be satisfactory in terms of exclusiveness, enforceability and certainty, to develop a market mechanism.

The “public characteristics” of some water uses imply that parties affected by water trades may not always be represented in the market. The benefits of improving the use of water resources through the market will depend on how these issues are dealt with when tradable water use rights are defined. Capacity sharing has the unique feature that the above-mentioned parties (mostly previously disadvantaged and minority groups) could be accommodated as a single shareholder⁸ within the capacity-sharing regime.

One of the difficulties in defining property rights for irrigation water and water per se is that the net use of water by crops (consumptive use) is generally far less than the total volume diverted to irrigate those crops. On the other side of the spectrum is the urban use where consumptive use is an even smaller portion of the total diverted volume. The difference between the consumptive use and the total volume diverted from the main drainage system is known as the return flow. These return flows could hold negative or positive externalities for downstream uses, depending on the current use pattern. If water price determination is based on the diverted use, private decision-makers will have an incentive to use as much of the diverted water as possible, because the return flow will be considered as a loss to that user. Therefore, upstream users have no incentive to accommodate downstream users. If the upstream user is paid for his return flow, there will be an incentive to divert only the needed volume of water (consumptive flow), therefore it should be argued that water price determination should be based on the consumptive use of water resources and not on the diverted volume.

However, given that the consumptive use of urban uses is even smaller than that of agricultural-related uses, the non-consumptive urban use plays a far more important role in determining the needed volume of diverted water. In other words, relative to agricultural use patterns with “bigger” consumptive uses (the net amount of water that is removed from the drainage system) the

⁸ For example, 100 small farmers form one capacity share. It should be noted that these farmers would need to have similar water use patterns. This single share will then be managed as a common property.

return-flow related uses⁹ for urban areas are bigger. It is clear that non-consumptive use is more important for urban use patterns relative to agricultural use patterns. It would therefore be naïve to base the definition and pricing of water use rights only on the consumptive use of water. Capacity sharing defines water use rights in terms of percentage of the total storage capacity (no open access or common property on stored water exists) and percentage of the total inflows within the season. It is possible for a specific user to have only inflow shares and no capacity shares. Each shareholder (which includes consumptive and non-consumptive as well as in-stream and off-stream users) will have an incentive to save water (economic gains associated with savings) because each shareholder is responsible for the management of his own capacity and inflow share and the additional cost incurred in the determining of the exact needed amount of water to be diverted will be justified by water-saving incentives such as economic gains from water saving.

Capacity sharing does have some obvious benefits associated with giving users more autonomy in managing inter-temporal reliability, but would need a detailed institutional arrangement in order to function effectively. In addition to the market for storage capacity, there would need to be an associated spot market for water and clearly defined rights to inflows.

Given the above-mentioned discussion on some of the complexities of water use rights, it should be clear that the rent-seekers would face difficulties exercising their lobbying power in order to enhance their individual preferences regarding water supply.

3. CONCLUSION

It should be clear that capacity sharing is not excluded from opportunistic behaviour due to problems of asymmetrical information. The concept do present however some resistance against adverse selection/moral hazard and rent-seeking behaviour, but will not eliminate it completely without some alternations.

The reason for this natural resistance against these problems are to be found in the stronger emphasis on privatisation and independency between

⁹ *The urban sector has a small consumptive use demand for drinking, cooking and gardening-related needs, but the biggest amount of water diverted for urban use goes to return-flow related uses such as personal hygiene, general household and industrial cleaning purposes, cooling (depending on the technology used) and sewerage.*

decision-makers within capacity sharing which is made possible through the decentralisation of management and integration of management functions.

Opportunistic behaviour will become more evident as water user associations are successfully transformed from previous water institutions (like irrigation boards) and a market based water allocation mechanism starts to unfold. Capacity sharing does offer resistance against opportunistic behaviour and the applicability and viability of the concept should be investigated on the level of the water user association.

REFERENCES

DUDLEY NJ (1988a). A Single decision-maker approach to irrigation reservoir and farm management decision-making. *Water Resources Research* 24(5):633-640.

DUDLEY NJ (1988b). Volume sharing of reservoir water. *Water Resources Research* 24(5):641-648.

DUDLEY NJ (1990a). Urban capacity-sharing-An innovative property right for maturing water economies. *Natural Resources Journal* 30(3):381-402.

DUDLEY NJ (1990b). *Economics of irrigation water allocation under uncertain conditions*. Centre for Ecological Economics and Water Policy, University of New England, Armidale, NSW, Australia.

DUDLEY NJ (1990c). *Alternative institutional arrangements for water supply probabilities and transfers*. Centre for Ecological Economics and Water Policy, University of New England, Armidale, NSW, Australia.

DUDLEY NJ (1992). Water allocation by markets, Common property and capacity sharing: Companions or Competitors? *Natural Resources Journal* 32(4):757-778.

DUDLEY NJ (1994). *An innovative arrangement with the potential of improving the management of international water resources*. Centre for Ecological Economics and Water Policy, University of New England, Armidale, NSW, Australia.

DUDLEY NJ (1999). *Integrating environmental and irrigation management in large-scale water resource systems*. In: Mahendrarajah S, Jakeman AJ & McAleer M (eds), *Modelling change in integrated economic and environmental systems*. John Wiley & Sons Publishers.

DUDLEY NJ & BRYANT MJ (1995). *The concept of capacity-sharing and responses to questions posed on implication for irrigators*. Centre for Ecological Economics and Water Policy, University of New England, Armidale, NSW, Australia.

DUDLEY NJ & MUSGRAVE WF (1988). Capacity-sharing of water reservoirs. *Water Resources Research* 24(5):649-658.

GAKPO EFY & DU PLESSIS LA (2001). *Alternative water institutional framework to meet the changing agricultural environment in South Africa*. Paper delivered at the 39th Annual Conference of the Agricultural Economic Association of South Africa, Champagne Sports Resort, Natal.

GAKPO EFY, DU PLESSIS LA & VILJOEN MF (2001). Towards institutional arrangements to ensure optimal allocation and security of South Africa's water resources. *Agrekon* 40(1):87-103.

LIPSEY G & GOURANT PN (1996). *Economics*. Harper-Collins Publishers, New-York.

SCOTT A & COUSTALIN G (1995). The evolution of water rights. *Natural Resources Journal* 35(4):821-978.

VILJOEN MF, DUDLEY NJ & GAKPO EFY (2000). *A methodological perspective on valuing water: A comparison between linear programming and stochastic dynamic programming*. Paper delivered at the 38th Annual Conference of the Agricultural Economic Association of South Africa, Sun City, South Africa.