Utilising Water: Some Economic Issues

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For at least thirty years Australia has been a mature water economy with demands in excess of supply (Randall 1981). There are both short run allocation decisions and long run investment decisions. In the short run, limited water supplies have to be allocated between human consumption, industrial inputs, irrigated agriculture, recreation, environmental purposes, and other uses. While many of these uses have private good properties and this suggests the use of market allocative mechanisms, the prevalence of public good properties and of externalities result in market failures. Longer run investments in storages, water treatment works, R&D and so forth can shift the demand for and supply of water, but these investments have to compete with other investment options in the economy. This paper provides an economic framework for evaluating institutional structures and operating rules for the allocation of scarce water resources among competing uses and for investing in increases in water quantity and water quality. For illustrative purposes the framework is couched in the context of the Murray - Darling Basin.

The paper is structured as follows. The next section describes in more detail some of the water allocation and investment choices for the Murray - Darling Basin, and it describes the economic properties of goods and services produced and consumed. Ideal water allocation and investment rules to achieve allocative efficiency are presented in Section 2. Section 3 describes past and current decision procedures and results, and it highlights some of their outcomes against the criteria of an efficient allocation of water and investment strategy. The relative merits of government intervention via rules and regulations, prices, taxes and tradeable permits affecting the availability and use of Murray - Darling Basin water are discussed in Section 4 in terms of efficiency, equity and feasibility criteria. A final section provides some conclusions.

1. Water as a Scarce Natural Resource

The water resource in the Murray - Darling Basin, as is the case for most other Australian river systems, is based on a low average rainfall per hectare and extreme variability. Constructed water storages considerably reduce downstream flow variability, but these investments have important environmental effects.

There are a large number of competing uses for the limited water resource. Irrigation to increase agricultural production is the largest user by volume. Annual agricultural output in the Murray - Darling Basin is around $5 billion (Quiggin 2001). In turn, irrigated agriculture embraces many competing products, such as fruits, vegetables, rice, cotton and pasture, and there are competing irrigation areas in Queensland, New South Wales, Victoria and South Australia. Humans and industry in Adelaide and inland cities depend on the Murray - Darling for much of their household water and industry input water. The river system's waterways provide recreation in the form of, for example, swimming, fishing, hiking, camping and viewing flora and fauna. River systems, including the Murray - Darling, provide a range of environmental amenities such as flora and fauna, estuarine, heritage and cultural links. Rivers also are used for the disposal of wastes. Other uses of river water include transport and hydro electricity

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generation. With current rights and prices the demand for Murray - Darling water exceeds the available supply (Quiggin, 2001).

Methods for allocating limited water, and in particular the relative effectiveness of market prices versus government command and control allocative mechanisms, depend on the mix of rival and excludability properties of the different uses of the water. Many of the uses, including for irrigation, for human consumption and as industry inputs, have the private good properties of rival consumption and excludability. Well defined water property rights and market prices can effectively allocate scarce water among irrigators, industries and households.

A portion of the environmental values of the Murray - Darling Basin can be best described as public goods characterised by non-rival consumption and high costs of exclusion. This is particularly the case of existence values for flora, fauna and the river system. Here the free rider problem is endemic and markets will under allocate water for environmental amenity usage.

Recreation uses of the river system are mixed goods characterised by non-rival consumption, until congestion becomes an issue, and with relatively low costs of exclusion. Effective market operation with mixed goods requires monopoly price discrimination.

Of major importance to any assessment of the efficiency effects of the allocation of Murray - Darling water is widespread external costs associated with incomplete property rights. Some areas and forms of irrigation result in irrigation water additions to the water table resulting in water logging and salination downstream. In many cases these external costs take place hundreds of kilometres away and tens of years in to the future. More saline water in the downstream river caused by upstream water withdrawals and by drainage imposes external costs on downstream users, including irrigators and Adelaide residents and industry. External costs also arise from use of the river system as a dump for household, firm and farm wastes, with algae blooms being one example. From a society optimisation perspective, too much of the limited water is allocated to the externality cost creating activities under markets, and also under the current command and control regulatory system.

Investment can change the quantity and quality of water available for the different uses. Public construction of dams over the first half of the twentieth century and the Snowy Mountains Scheme of the 1950s have increased the reliability and year round useable supply of water in the Murray - Darling Basin. Investment in reticulation systems, including pipes, can reduce water loss via evaporation and seepage. Waste treatment of sewage and industrial waste improves water quality. Investment by households and businesses in water efficient equipment and by farmers on land levelling, irrigation systems and species choice can reduce water use per unit output. Investment in pumps, drainage systems and even in water desalination have been undertaken. Importantly, investment in R&D in a wide variety of areas such as hydrology, plant genes, can be used to reduce water demand and effectively to increase available supply.

As was the case with the allocation of water to different uses, the products of investment to increase water supply have a mixture of private good, public good and mixed good properties, and some investments are likely to incur external costs and benefits.

2. Achieving Efficiency

Simple principles with important implications, and no doubt some difficult-to-apply issues, need to be satisfied to achieve an efficient allocation of water resources among different uses and in choosing investment levels. An efficient or aggregate society welfare maximum allocation of water among different uses would equate marginal social benefits for the last litre of water allocated to each different use. Formally

$$MSB_i = MSB_j \qquad (1)$$

where MSB denotes marginal social benefit and i, j represents use of the last litre of water by, for example, cotton irrigation in the Wee Wau area, by grape irrigation in the Riverland, by households in Albury and Adelaide, by use of water to sustain a wetland or protect red gum forests, and so on. Socially efficient investments to increase storages, to pipe water, to improve drainage, to capture salt, for R&D, and so forth should be undertaken if the expected present value of additional benefits exceed investment costs, formally

$$\sum_k MSB_{t+k}/(1+r)^k \geq MSC \qquad (2)$$

where MSB_{t+k} are marginal social benefits in year t + k, r is the discount rate, and MSC is marginal social cost; note that MSB of (1) and (2) are the same terms and in this way water allocation and investment decisions are linked.

An illustration of the benefits of reallocating water to equate marginal social benefits is given in Figure 1 for the special case of a fixed supply O_iO_j and two uses, i for cotton irrigation and j for Adelaide households. If the initial allocation is O_iA_1 to cotton and O_jA_1 to households, marginal social benefits for households at M_j exceed those for cotton at M_i by ST. Reallocation of scarce water from cotton to households up to A* will generate an efficiency gain of area RST. Note that the efficiency gain increases more than proportionally with the differential between marginal social benefits, and that the efficiency gain is greater the more elastic or price responsive is water demand in the different uses.

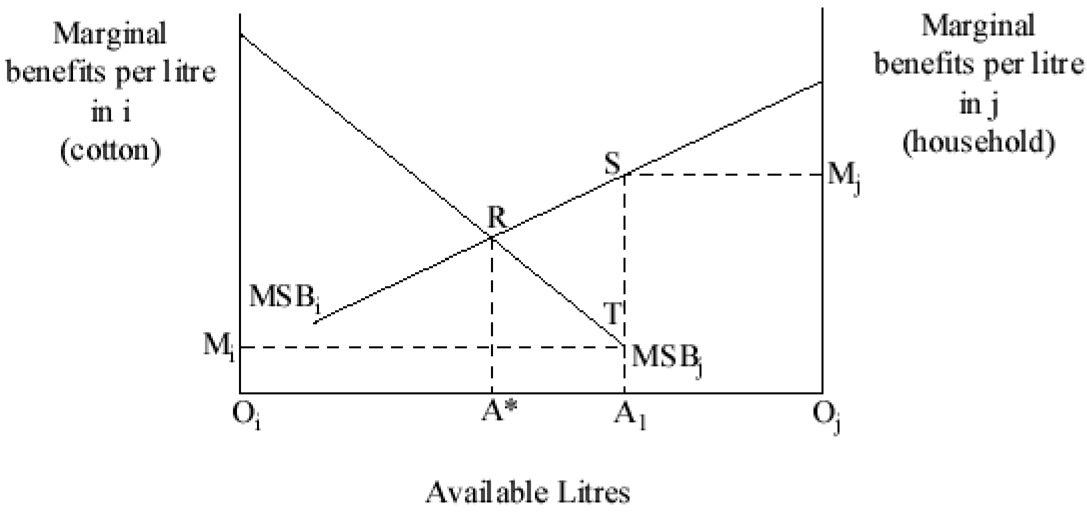

Figure 1

Where alternative water uses are private goods and there are no external costs, marginal social benefits equal marginal private benefits. Here, a competitive water market with price as the coordinating allocater would achieve the most efficient water allocation with

$$MSB_i = MPB_i = P = MPB_j = MSB_j \qquad (3)$$

where, as before, MSB is marginal social benefit, MPB is marginal private benefit, and P is the market clearing price. Price measures the social opportunity return or cost of water.

In situations where water use involves external costs, marginal social benefits will differ from marginal private benefits by marginal external costs, MEC, namely,

$$MSB = MPB - MEC.$$

Use of a competitive market and prices to allocate water will result in too much water being allocated to the externality creating activities and too little to other uses. There then is a necessary set of conditions for government intervention by taxing the externality uses or by quota rationing for example to effect a reallocation of water to equate marginal social benefits across different issues.

Figure 2, which builds on Figure 1, illustrates. Again there are two uses of the water, cotton and households, but this time assume cotton irrigation also results in external stability costs but household use generates no external costs. Then, the marginal social benefit curve for cotton MSB_i lies below the marginal private benefits MPB_i by the marginal external cost MEC_i, so that $MSB_i = MPB_i - MEC_i$. The efficient allocation of water between cotton and households is given at A_2 where $MSB_i = MSB_j$.

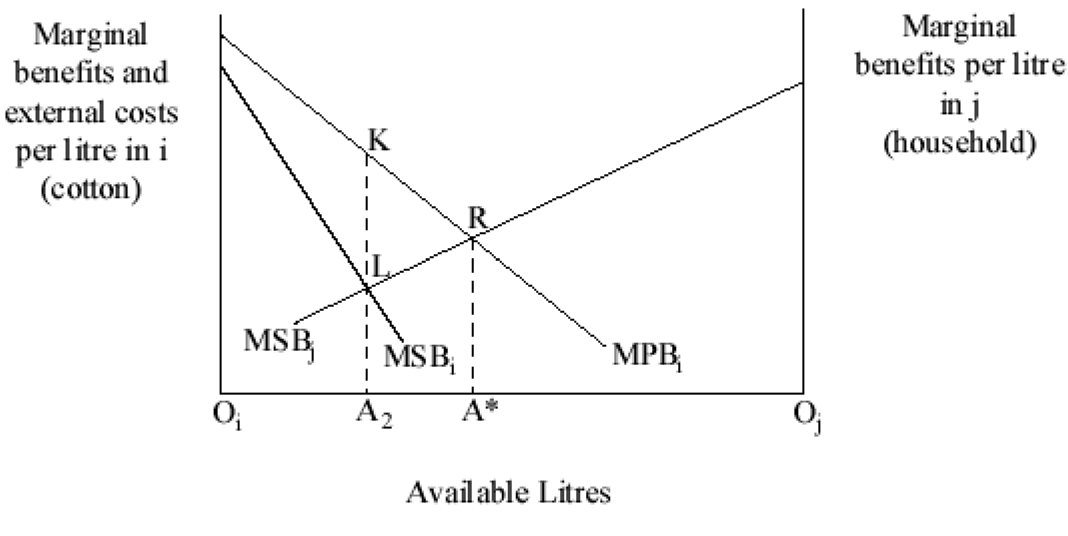

Figure 2

An important result of the externality story is that, typically, the efficient allocation of water will include some allocation to the polluting or externality creating activities. Because society values products produced by these activities, in this illustration cotton, seldom is it in society's interest to ban such production or to have zero pollution.

Where uses of water have non-rival consumption properties, including some public good environmental amenity values, marginal social benefits for that use MSB_l is given by the sum of marginal private benefits MPB_{lk}, where k denotes different individuals. Formally, for public good uses of water

$$MSB_l = \sum_k MPB_{lk} \qquad (4)$$

Because of the free rider problem, markets will under-allocate water to public good uses. Also, from a government intervention perspective, individuals do not have incentives to reveal their preferences and this gives rise to opportunities for government failure as well as for market failure. Techniques such as contingent valuation studies are only partly successful in assessing society values for public goods.

An other important set of messages from economics on the use of water and on investment is that decisions up to now represent decisions which cannot be changed, the investments already made represent fixed costs, and that our future decision starting point is the present pattern of allocated rights and pollution. This means, as highlighted by (2), that future investment decisions should be evaluated in terms of the future flows of additional benefits and costs associated with the investment. Estimates of the pollution costs of past decisions, other than as an interesting historical analysis, have relevance to current and future decisions only in as much as they give a guide to the marginal benefits and costs of current and future decision choice options. Similarly, basing decisions on the criterion of restoration of the pristine or other benchmark environmental outcomes will enhance society welfare only if they pass the social marginal benefits is greater than the social marginal costs criteria.

3. Past Murray - Darling Basin Decisions

The riparian rights system introduced in the nineteenth century, and largely in tact up to the 1980s, still has a large bearing on the allocation of water. Water and land rights were combined as a joint product so that those with land adjacent to rivers and canals had rights to use water. They gave rights to use the water at zero price. Negligible consideration was given to environmental uses and external effects were ignored to a large extent.

Governments funded the construction of dams and water distribution networks driving the first half of the twentieth century. Motives of promoting population growth and agricultural development, plus the electoral appeal of building dams, dominated any formal economic or environmental assessment of the worth of projects (Davidson 1969). By the 1960s formal benefit cost analysis was considered, and by the 1980s some consideration of environmental sustainability entered the water debate.

By the late 1980s public policy towards the use of the water resources of the Murray - Darling Basin had shifted in response to recognition that demand was greater than supply and with the rising concern for environmental effects. The Murray - Darling Basin Agreement provided an institutional structure for coordinating management of the Basin as an integrated system. Quotes on usage by States and regions have been imposed. There have been steps to separate the ownership of land and water enshrined under the riparian rights system, to allow for limited transferability of water rights. Most States have sought to raise the price of water, initially to cover operating costs and then to make a contribution to capital costs. There has been discussion and some formal quotes to explicitly allocate flows for environmental amenity. Also, several $100 million have been promised by governments for capital expenditure.

There is considerable evidence that the scarce Murray - Darling water resources are not allocated efficiently. Farm gross margin studies of different irrigated crops in different regions differ widely, with these differences not explained by corresponding differences in relative external costs. Prices paid by urban water users are very much higher than those paid for water used for irrigation. Models of parts or all of the Basin indicate that reallocations within agriculture would lead to significant increases in net agricultural output (eg. Quiggin 1988, Topp and McClintock 1998, Sappideen, Kennedy and Dumsday 1998, and Hall, Poulter and Curtotli 1993). Without considering the contentious issue of the marginal social benefits of environmental amenity uses of water, there is ample evidence that the marginal benefits of other uses of the Murray - Darling Basin water resources are a long way from being equal.

Formal benefit cost analysis of proposed investments in pipes, salt extraction, tree planting and other publicly funded projects seems to be limited.

4. Future Management Directions and Challenges

A mixture of enhanced market mechanisms for private good uses and of more formal social benefit-cost assessments for public good uses of the Murray - Darling Basin water resources have the potential to improve on current scarce water allocation and investment appraisal procedures and outcomes.

Most of the environmental values of plant and animal diversity along the rivers and estuary have the public good properties of non-rival consumption and high costs of exclusion, and it is likely that many of the Basin's recreation uses also have non-rival properties with congestion not being an issue. Allocation of water resources for these purposes will require an explicit quota of water flows backed by government regulation or an allocation of water rights to a "representative environmental amenity consumer".

A formal benefit cost study would be a useful framework for organising required information to make a judgement about the environmental flow water allocation. In particular, the analysis would need to articulate the biological functions linking water flows to desired flora and fauna biodiversity and other environmental amenity benefits. Then, the difficult step of placing marginal social values on additional environmental services cannot be ignored or bypassed. These benefits have to be compared with the opportunity costs of using the river flows for irrigation, Adelaide households and other private uses. The time profiles of benefits and opportunity costs would be discounted to obtain net present values. In principle, the environment quota would be chosen to equate social marginal benefits with the social marginal opportunity cost of using the limited water for other purposes.

It would be a surprising coincidence if the 1993 - 94 cap now in place on private good uses of the river, and by implication that left for environmental purposes was close to the socially efficient allocation of Murray - Darling waters to environmental flows. If society values a higher allocation for environmental purposes, one option is for governments to buy water rights from irrigators, Adelaide, and other current private good users. Another option is to fund investments which increase water flows which then are allocated to environmental uses.

The remaining water flows become available for allocation among private good uses of irrigation for different crops and different regions, household use in different cities and towns, industry use, and so forth. Ideally, water would be rationed among the different uses to equate marginal social benefits. If prices are used, these prices would be determined not with reference to costs of supply, and hence dispensing with fruitless debate about whether short run marginal cost, long run marginal cost, average cost, etc. but with the price where demand equals the available supply, itself essentially perfectly inelastic. Alternatively a system of tradeable water rights would lead to market prices at which demand and the quota supply interact, but here the market trading of water rights endogenously determines the required price. Drawing on the Coase theorem, the initial allocation of water rights has no adverse effect on achieving an efficiency outcome, but the initial allocation has distributional and equity effects.

Allocating water rights to historical users based on their usage in recent times (as opposed to other options of auctioning the rights, first come, first served) has some equity and political appeal features. Among other things, this means that unused "sleeper" rights would be expunged; but then no real loss is incurred because the revealed non-use of the rights indicate that these rights yield zero value to the holders. Beginning with the historical rights allocation, any transfers then will be Pareto wealth improvements for both buyers and sellers, as well as generating efficiency gains.

External effects of water used for irrigation, including waterlogging and salinity effects on other farmers in future years, need to be considered in modifying a system of tradeable water rights and any water prices. The initial point is to establish the magnitude of external effects, both physically but also the dollar costs. In particular, do the external costs vary by region, product irrigated, irrigation system and management methods, and with other measurable characteristics? If and where relative external costs vary, there is a potential case to alter the one to one transferability of water rights to reflect relative external costs. For example, if external costs for crop C in region M are double those of crop G in region M or of crop C in region L, social efficiency would be improved if there was a tax on water used for crop C in region M (equal to the additional external cost), or the exchange rate of water for crop C in region M would be less than one for one of the other irrigation uses. Presumably these types of consideration lies behind current rather stringent restrictions on water right transfers being restricted to within a region or only from high externality regions to low externality regions. Such binary restrictions reduce the size of water markets and the potential set of efficient reallocations of water.

An effective system of transferable water rights raises a number of other practical issues discussed by Brennan and Scoccimarro (1999). These include the clear and explicit specification of property rights and the need for a competitive market trading rights. Property right specifications include volume, time of supply, reliability of supply, and clearly a number of different resources with different levels of supply reliability will need to be established, annual charges to cover incremental and operating costs, and any restrictions on transferability because of externalities. The lower the transaction costs, and the larger the set of potential buyers and sellers, the larger and more competitive will be the market, and in turn the more effective will be the system of transferable water rights in reallocating scarce water to higher value uses.

The market price of transferable water rights provides a good measure of the value of investments to improve the quantity, reliability and quality of additional water. The market price can signal private investment and management changes, and it can be used in formal benefit cost studies of future public investments. Importantly, an explicit price for water provides incentives and rewards for the development and adoption of technology to save on the use of the scarce water input. With expected increases in demand for water in the future the value of this ever-present pressure to improve technical efficiency of water use cannot be overestimated.

5. Concluding Comments

The efficient allocation of scarce water resources between different irrigated crops, households, industry, recreation, environmental and other uses requires that marginal social benefits be equated. The prevalence of private good properties of irrigation, household and industry uses of water suggests a market allocation mechanism based on freely traded transferable water property rights can be used for allocating water among those private uses. Here, the market price is the allocative mechanism, it signals returns from further investments, and it provides a measure of opportunity returns in benefit cost evaluations of more or less environmental flows. Where external costs of water use are important, and especially where the relative external costs vary across different uses, it becomes necessary to add externality taxes or to multiply the rates of exchange between water used for different purposes with different relative external costs.

Economic allocative efficiency rules are likely to be at variance with a number of common misperceptions about the allocation of water resources. Where production of valuable products using water as an input incur external costs, in most cases the socially efficient allocation will involve some external costs, and not zero external costs. Investment decisions on storages, pipes, salt extraction and so forth should be made with respect to expected future marginal social benefits and costs. Past decisions and investments are bygones, and attempts to recreate a past pristine state are unlikely to be near a socially efficient answer to the question of what to produce and how.

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Background

After graduating with a PhD from the University of California (Davis) in 1972, John Freebairn worked at the NSW Department of Agriculture until 1974 where he was senior economist.

John became a Research Fellow at the Research School of Social Sciences at ANU in 1974 before moving as a Professor of Agricultural Economics at La Trobe University from 1977 until 1984. From 1984 until 1986 John took over the responsibilities of Research Director at the Business Council of Australia.

John joined Monash University in 1986 as Deputy Director in the Centre of Policy Studies. In 1991 he shifted to the Department of Economics at Monash and at various times was Chairman of the Department and Deputy Dean and Dean of Faculty. John joined The University of Melbourne in 1996 and became Head of Department in 1997.