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Economic analysis of greywater recycling

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Abstrac t
Until recently, economists classified water as a *'Free Good';* currently, water scarcity resulting from the 2000-2003 drought conditions and improved scientific understanding of salinity, have Australian water managers started reviewing valuation policies. Universally there is increased recognition that water is a finite [scarce] resource with economic value and associated opportunity costs. These policy changes contrast with the last half-century when Australian governments' adopted strategic policies of selling the service of treating and supplying urban water. The pricing associated with water reticulation was used to justify capital expenditure as well as for short-term political gains. As water supplies are recognised as scarce, pricing has become increasingly subject to government intervention while inefficient policies are distorting market values. A major cause of price distortion impinges upon emotive-based environmental issues that have been politicised without considering the trimorphism of social, economic and environmental analysis.

Socially, conservationists' objections to recycling household greywater from bathrooms and laundries are diminishing, albeit whether this recycled resource should be for individual gain or the betterment of society generally. Economically there is increasing incentive for consumers to maximise the utility gained from the purchase of treated reticulated water, with the use of greywater being identified as a landscaping resource. Environmentally Australian water agencies adopt contrasting policies regarding greywater reuse, without scientific justification.

A burgeoning analytical framework, Triple Bottom Line (TBL), is presented as a means of achieving best water management practice as well as explaining what could be considered as irrational consumer economic behaviour. This paper employs this framework for assessing greywater recycling by examining the financial costs borne by the homeowner in meeting the regulations for greywater treatment, and comparing these with devices for minimising water consumption, and collecting and storing rainwater. A brief analysis of the environmental and social implications will also be made as these have been neglected in current reactions to drought. It is concluded that the cost of meeting regulations for recycling greywater is distorted by failure to utilize comprehensive comparative analysis techniques due to government intervention based on partial, rather than holistic, analysis.

Keywords
Benefit cost, greywater, opportunity costs, rainwater, recycling, triple bottom line.

INTRODUCTION

Recent low rainfall conditions across eastern Australia and the associated draw down on metropolitan water supplies have required authorities to invoke mandatory water restrictions to limit urban water use, after voluntary restrictions failed to meet expectations. These conditions have also created a serious conundrum for governments where there is a need to encourage water reuse while at the same time depending on sewerage discharges to maintain flows in certain waterways, as is the case in South Creek in western Sydney.

Sydney's mandatory restrictions, which apply to one in four Australians, clearly distinguish between domestic water use [in-house such as showers, toilet, kitchen and laundry] and non-domestic use [car washing, lawn maintenance and garden watering]. Table 1 records the seriousness of three major city water storages.

Table 1. Water Consumption and Percentage Storage Capacity by City: December 2003

Location	Av. weekly water consumption [ML]	Storage Capacity %	Restrictions Reduction [%]	Date Source
Sydney, Illawarra & Blue Mts.	10,559#	55.3	16.7*	Sydney Water, 2003
Melbourne	10,500	57.1	15.0+	Melbourne Water, 2003
Canberra	2,500	58.7	12.0	www.actew.co m.au
Perth- surface 50%	5,600	34.3	NEA	WA Water Corporation, 2003
- Groundwater 50%		NEA	NEA	
- Bores 80,000 *	5,600	NEA	NEA	Uni. of Western Australia, 2003

* Mostly for gardening and landscaping. NEA = No estimates available. # = Long-term 12,645. + = Target

Additionally, the NSW Premier has announced that Sydney's restrictions are permanent, to preserve current supplies during the current drought conditions as well as to accommodate the future population expansion without constructing additional water infrastructure such as dams. The premier's policy is part of a broader environmental conservation program, to which there are many social and economic [TBL] implications. Predominately household water restrictions apply to external water uses, such as for washing cars, hosing down paths, irrigation of lawns and gardens. Supplementing these restriction is 'encouragement' for householder to install low pressure show heads and dual flush toilets while ignoring high wastage resulting from hot-water draw-off and hot-water tank overflows. While many of the external uses of water can be replaced with less consumptive practices, [*e.g.* window washing from a bucket, sweeping concrete paths, or using professional car washing facilities], there are direct social opportunity costs such as diminished aesthetics of city's gardens and parklands. For individual households there are costs associated with loss of valuable plants or real estate values, neither measured in terms of water volumes or water pricing. It is these costs that provide consumer incentive for otherwise 'irrational' behaviour.

TRIPLE BOTTOM LINE

TBL is a burgeoning framework emerging from more than half a century of economics, and more recently by accountants, attempting to balance the trimorphism of values associated with human activities. Initially TBL was developed for annual business reporting purposes suggesting the end of the investigation and evaluation processes. Progressively TBL is assuming the role of the Environment Evaluation Systems (EES) developed in the 1960s where the social, economic and environmental evaluation is placed towards the start of any assessment process. The need to undertake assessments prior to development is supported by Elkington (1999) who posits:

"… increasingly we think in terms of focussing on economic prosperity, environmental quality and - the element which business has tended to overlook –social justice. To achieve balance implicit in the 'triple bottom line' concept, we need not only new forms of accountability but also new forms of accounting. If we are to manage a company's performance effectively, we need to be able to measure it. We must find accurate, useful and credible indicators of progress in terms of economic prosperity, environmental quality and social justice."

Whilst economists identified the need and developed the tools for measuring social and environmental values, these valuations were not generally accepted. For example, while the NSW Environment Planning and Assessment Act of 1979 indicates that social, economic and environmental factors should be taken into account when assessing any development, this philosophy conflicted with the application of the Land and Environment Court which discounted or at times refused to hear economic argument.

By offering these valuations within an accounting framework, TBL is providing a means for corporations [including government agencies] to recognise these valuing instruments within legal, policy and community governance perspectives. Within these contexts this paper reviews the performance of agencies that regulate the greywater supply.

WATER STATISTICS

Recently the NSW Department of Infrastructure, Planning and Natural Resources (DIPNR, previously Land & Water Conservation) (DLWC, 2002) reported social, environmental and economic indicators for water and sewerage services over the last 10 years. A selection of benchmarking indicators of social, environmental and economic performance of the NSW's reticulated water industry allow for spatial and inter-departmental comparisons, including:

- ***Water consumption*** **–** average annual water consumption to connected properties has fallen from 330 kilolitres per annum (kL/a) to 230 kL/a over the last 10 years;
- ***10-year average residential bill*** per connected property has increased slightly to $325 for water supply while decreasing slightly for sewerage to $335 (Jan 2001 $);
- ***Economic real rate of return*** [to government] has remained steady at about 2.6% for water supply over the last six years;
- ***The median water usage charge*** across all NSW water suppliers was $0.65 /kL; and
- ***Unmetered water*** (including leakages) was 10% of total consumption.

The ABS (2003b) estimated 2,365,700 homes or 95% of households in NSW were connected to mains water supply (October 2002). In Sydney, 98% of all households were connected to mains water compared with 89% for the rest of NSW. Of those households connected to mains water, only 2% in Sydney have an alternative (additional) source of water compared with 15% in the rest of NSW. The most common alterative sources were rainwater tanks and bores. Of the households connected to mains water, there are 3.1% (46,900) connected to septic tanks and 7.5% (64,100) for the rest of NSW (ABS, 2003b). From the ABS data, it is calculated that 134,000 households in NSW are without mains water and can be assumed to have septic tanks. In total, there may be 245,000 on-site systems in NSW. The recycling of wastewater in systems not connected to mains water will only impinge on individual's water availability with no impact on community storages.

PRICE OF WATER

The driving force for most consumers is 'consumer price', with social and environmental factors either ignored or devalued. Customers in almost all urban areas accept the availability of adequate supplies of drinking water as a given, and expenditures on water typically account for a minor part of their budgets (Shadwick, 2002). The results from ABS (2003a) indicated that only 62% of Australians were concerned about environmental issues, and that rate was falling. Brennan [1999] further showed that prioritisation of environmental concern was correlated to socio-economic factors, an important consideration when conservation policies are linked to pricing and community equity. To illustrate, 51% of Victorian households are most likely to practise water conservation (ABS, 2003a) from which it is deduced that these persons are influenced by ethical or socio-economic considerations. Of the remaining 49% of that population they are either ambivalent or deliberately ignore the financial or social costs of excessive water consumption. Shadwick [2002] states that volumetric pricing is inducing urban customers to save, through efficiencies in use and reduced consumption. These savings also lower the cost of treating wastewater. The current charges for mains water are summarised in Table 2 showing 2003 pricing structures for several selected locations. These differences between locations are further exacerbated by the fact that the socio-economic condition varies in each of these areas, with the city areas having the highest disposable incomes.

Of the 125 water utilities in NSW that provided water supply and sewerage services, 57 utilities (51%) has a two-part tariff (an access charge and a charge per kL for all water usage) or an inclining block tariff (access charge, a relatively low charge for usage say up to 200 kL/a and a higher charge per kL for greater usage) that comply with the Independent Pricing and Regulatory Tribunal's (IPART) Pricing Principles for Local Water Authorities and with the Council of Australian Government's (COAG) Strategic Framework for Water Reform (ABS, 2003a).

Table 2. Price of water to consumers in selected towns and cities*.

Town Water Supply	Tariff (step 1)	Tariff (step 2 if applicable)	Reference
Sydney Water	$0.98/kL		Sydney Water (by phone)
NSW combined	$0.65 per kL		DLWC (2002)
Armidale Dumaresq	$0.70 per litre for first 200 kL each six months	$0.88 for 201-500 kL and $1.15 all excess each six month	armidale.dlg.nsw.gov.au
Narrabri Shire Council	$0.33 per kL		narrabri.dlg.nsw.gov.au
Riverina Water County Council	$0.65 per kL for first 125 kL per quarter	$0.70 all excess over 125 kL per quarter	rwcc.com.au
Hastings Council	$0.85 per kL		hastings.dlg.nsw.gov.au
Brisbane City	$0.85 per kL		brisbane.qld.gov.au

* These prices are set by the authorities outside of the market mechanism.

Shadwick (2002) stated that the National Competition Council's (NCC) water reform framework for pricing of rural and urban water was to be achieved through consumption-based pricing, and full cost recovery, including a real rate of return earned by water suppliers, where current average rates of return are about 2.6%. While some authorities exceed this average, others have negative rates. Current NSW water-pricing reforms are designed to achieve better environmental and economic outcomes by having a fixed supply [*i.e.* no new dam construction] forcing diminished per capita demand for urban water using increased water prices. Government forecasts are that these reforms will result in improved private sector water use efficiencies and less wastage.

However, these NCC reforms ignore the socio-economic equity implications; water is a minuscule expense for the wealthy thereby only having an economic impact on the lower socio-economic groups or environmental value for those with strong conservation principles. In general, therefore, any financial savings that accrue to residents by reducing water consumption either by behavioural change or through greywater reuse options have no impact upon the wider community. To illustrate the Productivity Commission's modelling of the macroeconomic effects of the water reforms, it is estimated that the price paid by residents in the short-term would rise by 7.5% relative to supply price (Shadwick, 2002) - that is about $0.05 per kL. Compared to the market price for bottled water (over $2.50/L) this amount is of no financial or social significance.

GREYWATER REUSE

Two initiatives have received political acceptance in urban areas - the installation of rainwater tanks and recycling and reuse of greywater on suburban lots. From these initiatives arise benefit/cost implications for householders as well as the community's aesthetic values of an improved landscape. Socially, these initiatives have the potential of changing existing public apathy concerning potable water scarcity. Consequently, each factor is important in determining the trimorphism of social, economic and environmental values. The remainder of this paper examines the recycling of water from single domestic dwellings using simple accounting to show the futility of individual endeavours compared to aggregated expenditure in minimising water use. Other initiatives at the community level, and with support of the water authorities, can make greater savings of this scarce resource.

State Regulations

There are no scientifically based national water recycling guidelines, while inconsistencies of existing state guidelines presented in Table 3. Other than using a bucket to carry greywater to the landscaped area, the minimum requirement for greywater is primary treatment and subsurface discharge. Primary treatment is, therefore, a financial burden to those interested in recycling or reuse. At more than $1000 per installation, it is a futile exercise with no benefit from subsurface discharge. For greywater to have any value for recycling (toilet flushing, surface irrigation or subsurface drip irrigation) the treatment must be to secondary standard and chlorinated. The minimum cost of an aerated wastewater treatment system, is in the order of $8000. Any savings in purchasing potable water must be off-set against the cost of the treatment system over, say, 10 years.

Table 3. Variation of State Regulation of Greywater: Australia 2003

State	Method	Regulation
NSW	Diversion*	Diversion of greywater from the bath, shower or laundry without storage or treatment generally does not need approval; however, Hastings Council (NSW) permits the use of greywater from washing machines only during periods of water restrictions.
	Storage**	Permitted with treatment via a domestic greywater treatment system (DGTS) that provides collection, storage, treatment and disinfection. Approval by local authorities.
Victoria	Diversion	Method does not need council's 'septic tank permit' but approval is needed to alter the sewer connection; may only be used for subsurface irrigation.
	Storage	Permitted with treatment via a domestic greywater treatment system (DGTS) which provides collection, storage, treatment and disinfection. Output may be used for surface or subsurface irrigation. Environment Protection Authority is approving authority.
Queensland	Sewered area	greywater reuse is prohibited; must discharge to sewer (DNRM, 2003).
	Unsewered areas	Greywater is considered sewage and comes under the Onsite Sewerage Code; only when treated to secondary standard can it be reused.
South Australia	Primary treated	greywater must be disposed of subsurface, while surface discharge requires treatment and disinfection. Greywater systems are considered alternative on-site wastewater systems and require approval before installation.
Western Australia	Bucketing	Permitted without regulation.
	Primary	Must be distributed in below ground trenches.
	Secondary treated	Application by microdrip or spray irrigation; requires approval from WA Health before installation (20/30/10 for BOD5, TSS and FC)

* greywater diversion devices [GDD] either by gravity flow or through a pump diversion (that is not a storage tank)
** Performance guidelines are set for the DGTS for BOD, TSS and FC.

POTENTIAL GREYWATER SOURCES

Bathroom

The bathroom (bath, shower, basin) provides over 30% of the water that could be captured for recycling. While this water is contaminated by bacteria from humans, and contains soaps, greases and solids, there is no clear evidence that the surface soils are not able to effectively treat the water and negate risk of public health or environmental hazard.

Laundry

For houses connected to mains, 87.5% (2,070,000) have top-loading washing machines and 7.9% (186,100) with front-loading washing machines (ABS 2003b) and 4.6% with no washing machine. The average weekly washing done was 25.7% for 1-2 loads, 37.1% for 3-5 loads, 17.5% of 6-8 loads and the remainder with nine or more loads. The age of the washing machines were 25% less than three years old, 25% 3-5 years, 27% 6-10 years and the remainder either older or age unknown. Anecdotal evidence is that the average washing machine lasts 10-15 years, therefore, only half of the washing machines in current use are likely to be replaced in the next five years. This has implications for incentives to purchase low water use appliances because the time frame to gain from water efficiencies may be many years. It is unlikely that households will replace washing machines before they become uneconomic to repair. The chemical load of laundry water, depending upon the detergents used, may have a beneficial use for gardens and landscaped areas. Phosphorus [a finite resource] in laundry detergents provides an essential plant nutrient, although the sodium may be detrimental to soil structural stability.

Kitchen
In sewered areas, greywater from the kitchen is usually directed to the sewer because of the high solids and grease loads. In unsewered areas it is preferable to direct all kitchen wastewater to the septic tank. In either situation, kitchen water is not available for recycling.

Toilet
The blackwater from the toilet is not part of the greywater recycling strategy. The cost of treatment and disinfection to a level suitable for recycling in a single household is prohibitive

Swimming Pools
While swimming pools have no relevance to recycling, they are intimately involved with the use of water for filling and weekly top-ups. Of the houses connected to mains water, there were nearly 200,000 pools in Sydney and 82,100 in the rest of NSW (ABS, 2003b). Clearly, reduction in evaporation by the use of pool covers has the potential to save a considerable volume of water.

Savings in Water
The 20 000 ML saved by Sydney residents between 1 October 2003 and 22 December 2003 is a significant saving that has been done simply by curtailing external water use and awakening the public to the limited resource. It could not have been achieved in that period by domestic recycling or installation of water efficient devices. While the 'per person' water consumption fell by 7% for Sydney and 14% for Melbourne over the 10 years to 2000/01 (Shadwick, 2002) the average annual cost of water to households in Sydney rose slightly to around the $300 per residence (DLWC, 2002) even though the annual consumption fell from 330 kL to 230 kL. Estimates for the domestic use of water at various fixtures in a domestic dwelling are given in Table 4. These figures are estimates only and will change with occupancy rates and residents' actions.

Table 4. Estimates of domestic water use for a typical household (all units in L/day)

Facility	National #	Queensland*, Sydney Water*	Western Australia
Toilet	110	186	100
Handbasin		28	
Bath/Shower	145	193	160
Kitchen		44	
Laundry	110	135	130
Taps/0ther	65		110
Total per household	430	586	500

from GWA (2003) * Jeppersen & Solley (1994) cited in QLd DNR&M (2003)

From Table 4 the potential supply of greywater for recycling is a maximum of 400L/household/day or

146 kL per year [excluding kitchen and toilet]. At the Sydney price of $0.98/kL, the likely saving is $143 per annum less operating costs. Any savings in purchasing potable water must be off-set against the cost of the treatment system. Assuming a 10-year investment period, a recycling system that costs more than $1430 will be uneconomic. Since a primary treatment system will cost more than $1000 there is no economic benefit. For secondary treatment, the $8000 cost involves an investment exceeding 50 years at current water prices ($0.98/kL). Water prices would have to rise to $5.00/kL before secondary treatment of greywater was economic for some houses.

Assuming household behavioural changes could achieve a 20% reduction in greywater production, this reduction would result in annual savings of less than $78, making a treatment system of more than $780 uneconomic. This uneconomic situation is exacerbated by wet weather when even small events [*e.g.* insufficient to allow the lifting of restrictions], diminish or discontinue greywater use. Under these conditions greywater recycling is only valuable when restrictions are in place [*i.e.* an inferior good used in the absence of supply or the superior good]. This deduction is supported by hardware stores retailing devices aiding greywater diversion to surface discharge. These simple devices that can be installed by the do-it-yourself person are inexpensive, yet effective. These devices are marketed in both sewered and unsewered areas regardless of government regulation outlined in outlined in Table 3. Alternatively, Sydney Water (2001) suggests that water conservation devices save 20 kL/a for an average household [equivalent to $19.60/year]. Unless the cost of the suite of water saving devices to achieve this 20 kL/a saving is subsidised, the investment is uneconomic as the annual savings are less than the retail price for 10 x 600 mL bottles of water.

Retrofitting

Unfortunately, greywater systems cannot be retro-fitted to houses on concrete slabs or some multi-storey developments because there is no access to the separate pipes from the laundry or bathroom. In many locations, the installation of a secondary treatment system is not only impractical but also physically impossible because of access and land area for effluent application [including set back distances, drainage and other site constraints]. Recycling in urban areas is only suitable for a small number of blocks and, as discussed, uneconomic. It is a practical problem that for some systems, 6/3 L dual flush toilets have insufficient water to move solids through the pipes to the sewer.

Rebate Schemes

Most of the states are offering rebate schemes to retrofit water efficient devices into existing homes rather than wait for life-expiry before fitting. These rebate schemes are for low-flow showerheads, four-star rated washing machines, pressure limiting devices, dual 6/3L flush toilets. These initiatives are likely to be more cost effective than greywater recycling in sewered areas. In unsewered areas, water conservation is driven by different priorities, one being regular scarcity because of small storages and irregular rainfall.

CONCLUSION

Water conservation practices based upon mandatory restrictions are effective in limiting demand as shown in Table 1. Pricing policy and rebate schemes also provide encouragement to some consumers to install water saving devices, often at long-term savings. From current information it is reasonable to expect that greywater recycling is predominantly dependent on available water supply for domestic landscapes with only minimal reuse being based on conservation principles. This deduction is derived on the basis that current benefits/costs resulting from greywater use are prohibitive and generally exclude the low socio-economic sections of the community. Accordingly, greywater systems are not cost effective except in those cases where the landscape is more valuable than the price of the reuse program and there is no other water source. Further, from a social perspective, greywater reuse at a single dwelling, only has a minor, maybe immeasurable, role in water reduction during dry periods as its largest impact would occur at times of total restrictions. Greywater recycling and reuse may provide a factor of social well-being to their owners, but that same economic endeavour can achieve more in permanently reducing the domestic consumption of water. The cost of a secondary treatment system for greywater would be more than twice the amount required to retrofit dual flush toilets, low-flow shower heads, repair all taps, purchase a five-star rated washing machine and install a water efficient landscape plan.

From the water agency perspective, the most important gains are to be achieved from changes in community behaviour rather the installation of greywater treatment systems. Thus, in the absence of a market influenced pricing structure (water is currently too cheap) regulation is the only effective vehicle able to achieve water use reform. Government policies of rebates for retrofitting water efficient appliances, greywater treatment systems or rainwater tanks are political [social] instruments that have minor economic and environmental outcomes. In terms of social equity, regulation applies to all households regardless of socio-economic status whereas water pricing policies impact more greatly on households at the lower socio-economic scale. Over the long-term, public education in water use strategies will provide a means of altering community held values that in turn will alter the perception of the domestic landscape.

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