DEMAND SIDE APPROACHES TO WATER RESOURCE MANAGEMENT

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ABSTRACT

Global population growth has put enormous constraints and pressure on our dwindling water supply sources. Developed countries have traditionally placed emphasis on supply side options such as investment in construction and upgrading of water supply structures and treatment plants to meet water demand. A change in thinking, however, has occurred in the last few decades with water utilities and governments investigating and investing in alternative approaches to water supply and sewerage services provision. This emergence of a demand side approach is based on the principles of least cost planning and demand management that include options such as efficient use of water through reducing losses, improving the efficiency of water using equipment and processes, source substitution, for example, through use of rainwater tanks to reduce water demand from mains supply, and applying the principles of water quality cascade – treating water according to the end use, and reuse of wastewater.

This paper demonstrates the success of this demand side approach through four case studies undertaken by the Institute for Sustainable Futures and its staff. The case studies reflect the application of the principles of least cost planning and demand management at various levels to meet water demand. The paper also identifies opportunities for developing countries to adopt a similar approach to water and sewerage services provision that not only reduces or defers capital expenditure but also has huge social and environmental benefits.

INTRODUCTION

The dawn of the 21st century has seen the world considering four major challenges facing water supply planning (Whipple 1994). These include the continued growth in population putting pressure on water demand, the increase in pollution making many natural water sources unsuitable for supply, the growth of environmental controls such as environmental-flow requirements, with many water supply alternatives having been rendered unfeasible and finally, most rivers are now used for a variety of purposes, so a reservoir site or a given river flow usable solely for water supply may no longer be possible (Chanan & Simmons, 2002).

The massive increase in urban population has brought us to a stage where the balance of water supply and demand is close to being destabilised in many places. For decades, water utilities have adopted a traditional supply side approach to water management and planning. The emphasis, in such an approach, has been on increasing capacity to maintain system reliability and not managing or influencing the demand for water, which was considered unchangeable (Baumann et al, 1998). The supply side approach usually includes the construction, upgrading or augmentation of dams, treatment plants and pipelines to provide water supply and sewerage services.

A demand side approach is based on the principles of least cost planning and alternative water service provision. Least cost planning, or integrated resource planning, is a process of determining the lowest cost of providing a service, for example, how water service providers can provide their customers with the water related services they require at lowest cost to the water utility and the customer. The emphasis is on providing the service of supplying water and not the water itself.

Demand side options include efficient use of water through reducing losses, improving the efficiency of water using equipment and processes, source substitution, for example, through use of rainwater tanks to reduce water demand from mains supply, and applying the principles of water quality cascade – treating water according to the end use, and reuse of wastewater.

The benefits of adopting a demand side approach rather than supply side are the reduced and avoided infrastructure costs of water supply to the utility through the deferral or down-sizing of construction or upgrade of dams, treatment plants and pipelines, reduced operating costs, reduction in energy use and greenhouse gas emissions and other social and environmental benefits.

The aim of this paper is to present examples of the application of a demand side approach to water resource management by providing case studies, of projects undertaken by the Institute for Sustainable Futures (ISF) and its staff for various water utilities and state government organizations in Australia. The application of the principles described above is demonstrated in the following case studies.

CASE STUDIES

The case studies showcase the effect of a demand side approach on a micro level (water demand reduction in a commercial building), through to a macro level involving an entire catchment. Each case study demonstrates the advantages of utilizing a demand side approach in planning water service provision and planning.

Sustainable Water Management in a Commercial Building

This case study was undertaken for a major water utility in Australia to determine the potential water savings from a commercial high-rise building from various water management options. The options developed ranged from the use of water efficient fixtures to more complex options to achieve zero discharge to the sewer system.

To determine the potential water demand of a commercial building, a daily demand model was developed to determine the volumes of water required for the different end uses in the building. The results of the modelling showed that water savings of nearly 87% could be achieved through best practice water efficiency, capture of rainfall and effluent reuse compared to a traditional commercial building. Rainwater tank and evapotranspiration modelling was undertaken for the different options to determine the tank capacities required to store the rainwater and treated effluent respectively and also to determine the security of supply for each of the options. The options were ranked based on a cost benefit analysis. The highest ranking option involved the capture of rainwater from the roof of the building, the use of best practice water efficiency fixtures such as 5/2 litre dual flush toilets, waterless urinals, water efficient showerheads with user feedback and flow-regulated taps with infra red sensors, the collection and treatment of wastewater for toilet flushing with the excess effluent used for irrigation of the building's roof garden. The case study demonstrated how water demand for a commercial building could be reduced by 80% and sewage discharge by 90% compared to a traditional commercial building through efficiency measures and use of rainwater and treated wastewater in lieu of mains water supply for toilet flushing and roof garden irrigation. This reduction translates to significant dollar savings for the building developer in terms of reduced infrastructure charges (charges paid by the developer to the water utility for provision of water supply and sewerage infrastructure) for the development and to the building tenants in the form of reduced water bills. It was found that there was considerable overlap in the energy management of the building, especially in relation to energy use by pumps and choice of cooling systems and integration of some of the energy and water management aspects would yield increased benefits and reduced costs (Chanan et al, in press).

Jindong Broadwater Water Resource Use Efficiency Study

The Water and Rivers Commission of Western Australia initiated a study of the least cost means of improving the sustainability of groundwater resources in the Jindong-Broadwater sub area near Busselton in the South West of the State, by considering a range of strategies, particularly improving the efficiency with which water resources are used, but also looking at the possibility of substituting water resources, such as reclaimed effluent, surface water or water from less constrained aquifers.

The Leederville groundwater aquifer in the Jindong-Broadwater sub area may be over-allocated, and in order to guarantee the sustainability of the groundwater resource, action must be taken to reduce the impact of the current abstraction.

A number of possible strategies were considered in the study. These include aquifer recharge using reclaimed effluent, drawing water from the deeper groundwater resources (Sue Coal Measures), improving the efficiency of water use in nearby towns, Dunsborough and Yallingup, and improving the efficiency of irrigation water use.

The study indicated that the least cost strategy is to reduce the demand for water by irrigators through improved irrigation efficiency, particularly in the potato-growing sector, which represents over 60% of the water demand from the Leederville aquifer. The main method of achieving this is to improve the distribution of water applied to the crop, and improving the control of the irrigation process such that the crop obtains only the water it needs. Evidence from the region indicates that converting from wheel line irrigation systems to semi-permanent sprinkler systems can significantly improve the efficiency of water use, perhaps by 20-40% at an average cost of A$50,000 per farm. Coupled with improved irrigation scheduling based on soil moisture sensors, these changes at A$85 to A$170/ML of water saved, are likely to be cost-effective from an irrigator's perspective against the cost of diesel pumping (approximately A$120/ML). The reduction in labour costs due to the reduced need for shifting wheel lines is also significant. Other benefits of improved irrigation efficiency include better process control, which provides improved crop productivity and quality and reduces environmental impacts from runoff.

The study recommended that a water efficiency program be implemented in the Jindong-Broadwater region, based on a collaborative partnership between the stakeholders, including the Water and Rivers Commission, WA Agriculture, the Potato Grower's Association, other water users, and facilitated by a Program Officer with experience in irrigation or agricultural extension. There was an identified need for greater information flow and consultation with licensees regarding the constraints on the aquifer and the strategies that are available to address them. The process proposed provides a positive means of achieving this consultation, while also satisfying vital resource management objectives.

The total cost, from a whole of society perspective, of a least cost program for improving irrigation water efficiency was estimated to be approximately A$613,000, including the first year's salary of a Program Officer, the cost of converting irrigation equipment on 180 ha of potato farms, a demonstration computerised irrigation control system and the installation of soil moisture sensors on all farms. This represents the least cost option and has the potential to reduce the demand on the Leederville aquifer by between 312 ML/yr and 624 ML/yr, or 12 to 24% of the total Leederville allocation.

Implementing a water efficiency program in Dunsborough and Yallingup would cost approximately A$480,000 and could provide a water saving of 150 ML/yr or 6% of the Leederville allocation. The unit cost of the water saved would be approximately A$315/ML (ISF, 2002).

Rous Regional Demand Management Strategy – Rainwater Tanks as Distributed Supply

Rous County Council, a regional council in northern New South Wales, initiated the development of a Rous Regional Demand Management Strategy in 1996, following a report of the Rous Regional Water Supply Strategy Study. The objectives of the demand management strategy were to make recommendations on reducing water demand and also to undertake a cost benefit analysis using a least cost planning approach for the various options for reducing demand. The resulting report outlined the elements of a water efficiency program that targeted residential and non-residential customers. The elements of the program included regulation (water pricing, leakage reduction and policy), incentives (retrofitting for indoor and outdoor water efficiency, installation of rainwater tanks, reuse programs) and education (community education and awareness).

This case study focuses on the Rainwater Tank Program, that formed part of the Water Efficiency Program, which demonstrates the feasibility of using rainwater tanks to achieve self-supply.

The analysis of the potential use of the rainwater tanks was based on their use as a storage device with top up from mains supply, and as a substitute to mains water supply in new dwellings. Detailed raintank supply modelling was carried out for different tank capacities and roof areas. The results showed that self-supply could be achieved with a high level of reliability for a single dwelling, for certain configurations of tank volumes. However, this option was found to be higher in cost compared to other measures such as retrofitting showerheads or purchasing water efficient appliances for existing dwellings. If this option were to be pursued to reduce the demand from mains supply, then it would be favourable only after the installation of water efficient appliances and appropriate efficiency measures for outdoor areas as well.

The options were compared against a benchmark, which was set as the financial benefit of permanently and reliably reducing water demand in the region by one mega litre per year (1 ML/a). The financial benefits of installing rainwater tanks in new dwellings depend on the infrastructure charges the developer would have to pay. Calculations showed that rainwater tanks were likely to be a cost-effective alternative in some areas and cheaper in the long run to install and operate. The use of rainwater tanks as on-site detention devices was likely to provide financial benefits, especially in areas where the drainage system is at capacity.

The recommendations made by the report included community education and advice on the best use of the rainwater tanks and associated costs and benefits, investigation of the combined use of rainwater tanks for on-site detention and rainwater storage, and future development of rainwater tanks to form part of the water supply option for new buildings (Preferred Options, 1997).

Current investigations are being undertaken by ISF on the large-scale installation of rainwater tanks in the Rous region to reduce water demand from the dams.

Catchment wide Demand Management in the Hawkesbury Nepean

Sydney and the surrounding region's communities rely for their very existence on the Hawkesbury-Nepean river system. However, due to the demands on it, the river is slowly deteriorating and will be choked and polluted unless natural flows below the dams that supply Sydney's drinking water are increased. Apart from the dams and the weirs that reduce downstream flows the major causes of adverse affects on the river's health include, effluent disposal from sewage treatment plants, polluted stormwater from urban development and water abstraction for irrigation and town water supply.

Through its role on the Independent Expert Panel on Environmental Flows for the Hawkesbury- Nepean, ISF staff have been investigating the management of the water resource in relation to three critical demands placed on it:

- The demand for water by urban water users;
- Irrigation demand supplied by river extraction; and
- The demand for a healthy river that requires the allocation of environmental flows.

Meeting the demand for a healthy river requires either supply augmentation to meet the demands of water utility customers and irrigators or reducing the water resource demands from these two sources. A demand management approach involves both increased water efficiency and innovative servicing through re-use and source substitution. Meeting the demand through 'traditional' supply augmentation in the form of transfers from other catchments or desalination are extremely expensive options in both economic and environmental terms. Demand side management is both critical and, as our studies showed, cost effective from a whole of society perspective.

Reduction in demand from water utility customers is being achieved through pricing, education, water efficient appliances, industrial re-use, new landscape design and leakage reduction. Population growth is a powerful force eroding savings made at the individual consumer level and ISF studies have shown that key in managing this demand is around servicing new development areas differently. Through innovative water sensitive design of new residential development (including both water efficient appliances, landscape design and on-site re-use and recycling of potable water, stormwater, and effluent) hugely effective and economically efficient savings can be made. From all these programs the reduced hot water usage in the home also has flow on effects of reduced energy use and therefore reduced greenhouse gas production. In addition the potentially reduced urban run-off will have a positive impact on river health.

In terms of irrigation, water savings can be made in similar ways to town water through, improved efficient appliance use, better farm management (including more effective scheduling or effective use of storage) and the re-use or recycling of water from other sources. All of these demand side options have benefits beyond reduced water use and therefore increased environmental flows. These benefits include but are not limited to improved crop yield, reduced nutrient run-off and reduced costs for materials such as fertiliser. In addition, the option for re-using or recycling water has huge potential in the Hawkesbury Nepean. It could potentially provide irrigators access to a secure and nutrient rich source of water while reducing there demands on the river itself. . This approach addresses the potentially adverse effects of discharging the effluent directly into the river and potentially decreases the high treatment costs given the reduced need to treat the water to potable levels.

In both, the case of the water utility and the irrigator, the demand side approach was critical in this study. Wider than that, our studies have shown that time and time again the demand side approach carries the least cost to the community as a whole (including both environmental and economic impacts) whilst reducing resource use and forming a number of positive flow on effects. This is not to say that the supply side is not critical but taking only the supply approach often leads to less optimum outcomes.

CONCLUSIONS

The above case studies are based on the principles of least cost planning and demand management that are part of the demand side approach to water resource management and can be applied to relevant scenarios in any country.

Developed countries have traditionally been applying the supply side approach and investing in capital expenditure for water resource management. Utilities and governments are now realizing that such an approach, while solving the problems associated with water and sewerage services in the short term are not economical and sustainable in the longer run. Consequently, they are investigating the demand side approach to water service provision, which is not only economically viable and beneficial, but also requires lesser capital costs than supply side options.

The demand side approach illustrated in the above case studies is of particular relevance and usefulness in consideration of the needs of developing countries. These countries are in the process of investing significantly in new infrastructure to provide water and sanitation services to its population and to meet the growth driven by rapid urbanization. This is a major global issue not only in economic terms, but also in social and developmental terms, as recognized by the recently adopted UN goals on water and sanitation. The current strategies being implemented for provision of water and sewerage services in developing countries predominantly mirrors the supply side approach, that is now being actively questioned, and which has resulted in a considerable over-investment in infrastructure, environmental impact and resource use.

As the case studies demonstrate, there are enormous opportunities for developing countries, created by growth in demand for water supply services and new developments. The requirements for new services to meet standards of public health and developmental goals creates major opportunities to incorporate more efficient resource use up front, and to apply alternative servicing arrangements, such as distributed water supply and effluent treatment systems and best practice water efficiency, as illustrated in case studies One and Three rather than investing in large scale centralized systems for water management.

Many cities of the developing world have a per capita demand for water that exceeds that of some cities of the developed world. One of the major issues identified in an international report to the World Water Congress was leakage (White et al, 1999). A demand side approach would provide significant benefits in terms of resource use, avoided capital and operating costs and reduced environmental impact. For example, a preliminary survey on water use in Bangkok indicated that savings of over US$ 800 million could be achieved through implementation of demand management measures (Darmody et al, 1998). The reduction in capital and operating costs enables more appropriate allocation of investment into improved sanitation and health education in rural communities.

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