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A Role for Input-Output Analysis in Urban Water Policy Decisions in Australia

Chanan, Amit[a]*; Kandasamy, Jaya[b]; Sharma, Deepak[c];

[a] Director Assets & Services, Kogarah Municipal Council
2 Belgrave Street, Kogarah, NSW 2217.
Phone: +61293309458 . Fax:+61293309561.
E-mail: amit.chanan@kogarah.nsw.gov.au

[b], Senior Lecturer, Faculty of Engineering, UTS
Broadway, NSW 2000.
Phone : +61295142558. Fax : +61295142633. E-mail: jaya.kandasamy@uts.edu.au

[c], Associate Professor, Faculty of Engineering, UTS
Broadway, NSW 2000.
Phone : +61295142422. Fax : +61295142633. E-mail: deepak.sharma@uts.edu.au

*Corresponding author

Abstract

Discussion on water reuse and its role in sustainable water resource management in Australia has been on the agenda of policy makers and scientific community for the last three decades. Despite that, promulgation of water reuse especially in metropolitan Australia has been a rather slow process. To advance sustainable urban water management, water policy shift towards 'co-management' and 'higher value use' is critical.

Input Output Analysis provides an ideal mechanism for water policy makers to prepare a case for this much needed policy shift. The paper discusses the methodology available for such an exercise, with special reference to Kogarah Local Government Area, located within the Sydney Metropolitan.

Keywords: Water Reuse, Co-management, Input Output Analysis, Water policy, Non-potable reuse.

1. Background

Australia is the driest inhabited continent in the world, with over 75% of the land mass classified as arid. A further 10% is arid for much of the year and only 15% of the Australian continent can be described as '*well-watered*' (Taylor, 2002).

Under the Australian Federal System of Governance the responsibility to manage water resources rest with State Governments. Section 100 of the Australian Constitution prohibits the Government of the Commonwealth of Australia with regards to water resource management, leaving it in the hands of respective States. According to McKay (2005), this was the case because the '*Federation System was grafted onto and over existing Colonial Legislatures*' with a complex history of partisan politics. The Commonwealth Government nonetheless played a significant role in water resource management during the 20th century, through providing financial assistance to State Governments in developing large dams and associated water infrastructure.

In 1992, following the release of Agenda 21 and the resulting emphasis on sustainable development, the Commonwealth Government adopted a National Strategy for Ecological Sustainable Development (Taylor, 2002). The adoption of the ESD Strategy marked a significant shift in the emphasis from developing water resources to improving the management of these resources. Sustainability and economic viability were recognised as key drivers for water policy in Australia.

1.1 Industry Commission Review

It was at the same time that the Industry Commission (now Productivity Commission) gave its attention to water management policy. The Productivity Commission is Australia's principal review and advisory body on micro-economic policy and regulation, and is responsible for helping Government make better policies for the benefit of Australian community. The Commission carried out a review of water resource management in 1992, which was conducted with an economy wide view. It was perhaps the first time that the water policy in Australia was analysed beyond the immediate interests of water users and consumers, and impacts of water policy on other groups in the community such as the taxpayers and the environment were considered.

The Commission's review concluded that the existing water institutions in the country were inadequate to meet the future water resource management challenges (Industry Commission, 1992).This realisation led to the reforms of 1994 that saw the Coalition of Australian Governments (COAG) signing the Water Reform Agreement (McKay, 2005). The Water Reform Framework agreed by the COAG became the key driver for major changes in water management in Australia, in the following decade.

1.2 Water Reform Framework

The Water Reforms that commenced in 1994 were linked to the National Competition Policy. The reform agenda required all State Governments in Australia to ratify new water legislations, undertake structural reforms to facilitate competition and introduce independent price regulation for State owned water monopolies. The Water Reform Framework undoubtedly led to significant institutional changes in most Australian States.

However, despite the reform initiatives, the National Water Resource Audit of the year 2000 assessed that over a quarter of the nation's surface water management areas were water stressed, with extraction exceeding sustainable yield (McKay, 2006).

1.3 National Water Initiative

The most recent development in the Australian water resource management sector is the initiation of the National Water Initiative (NWI) in 2004. The NWI builds on the 1994 Water Reform Framework for the efficient and sustainable reform of the Australian water industry. The NWI recognises *'the need to increase the productivity and efficiency of Australia's water use, the need to service the rural and urban communities, and to ensure the health of river and groundwater systems by establishing clear pathways to return all systems to environmentally sustainable levels of extraction'* (Inter Government Agreement, 2004). Australian States and Commonwealth Governments also agreed to the establishment of the National Water Commission, to assist with effective implementation of the NWI.

It is important to note that McKay and Hurlimann (2003) identified lack of benchmark data and limited attention to water recycling, amongst the problems that limited the progress of 1994 water reforms. Notably, the NWI addresses both of these issues. The objectives of the NWI include - '*Water accounting which is able to meet the information needs of different water systems …*' (Department of Prime Minister and Cabinet, 2004). Furthermore, NWI also aims to '*encourage water conservation in our cities including better use of stormwater and recycled water'* (McKay, 2006).

2. Input Output Analysis

The emphasis on water accounting and realisation that the nation's future economic health depends on more productive water use sets an ideal backdrop for Input-Output (IO) Analysis to guide the Australian water policy. Velazquez (2006) suggested that to achieve sustainability of water consumption, it is necessary to know the relationships between economic sectors and water consumption. An IO Analysis is a useful technique for exploring these relationships.

<table>
<tr><th></th><th>Industry 1</th><th>Industry 2</th><th>Industry 3</th><th>Household consumption</th><th>Capital formation</th><th>Change in stocks</th><th>Total Outputs</th></tr>
<tr><td>Industry 1</td><td colspan="3" rowspan="3">Quadrant I
Intermediate flows from industry(row) to industry(column).</td><td colspan="3" rowspan="3">Quadrant II
Final Demand. Flows from industries(row) to final consumers(column).</td><td rowspan="3">Total outputs from industries</td></tr>
<tr><td>Industry2</td></tr>
<tr><td>Industry3</td></tr>
<tr><td>Wages etc</td><td colspan="3" rowspan="4">Quadrant III
Primary Inputs, Inputs(row) to industries(column).</td><td colspan="3" rowspan="4">Quadrant IV
Direct flows between primary inputs and final demand.</td><td rowspan="4"></td></tr>
<tr><td>Taxes</td></tr>
<tr><td>Surplus</td></tr>
<tr><td>Imports</td></tr>
<tr><td>Total Inputs</td><td colspan="3">Total inputs to industries</td><td colspan="3"></td><td></td></tr>
</table>

Table 1: Structure of an Input Output Table (Cox, 2006)

2.1 Input Output Analysis and Water Management

IO tables capture the operations of a production economy. According to Miller and Blair (1985), the fundamental purpose of an IO model is to analyse the interdependence of industries in an economy. The IO technique was first developed by Wassily Leontief in late 1930s, when he developed an IO table for the United States covering 96 sectors of the economy (Yang et al, 2007).

The application of IO Analysis to water policy is a relatively recent concept, only gathering momentum in the last three decades (Guan and Hubacek, 2007). Finster (1971) was amongst the earlier applications of IO techniques to water policy. Using an open IO model for Arizona to test his proposal, Finster (1971) called for a demand oriented water policy. Such an approach changes the total quantity of water demanded by a region through alterations in the external commodity trade pattern. By enabling interbasin transfers of water through commodity trade between regions, demand-oriented water policy results in efficient overall allocation of the country's water supply.

The remainder of this section briefly highlights some international examples of the use of IO techniques in developing water resource management policy. For instance, Harris and Rea (1984) used the IO model to allocate water resources by incremental value among alternative industries within a region. This work highlighted that water allocations based on property rights or other institutional arrangements, and not on a market mechanism, tend to misallocate water.

Hubacek and Sun (2005) utilised IO techniques to conduct forecasting of water consumption by the Chinese economy by the year 2025. This work developed regional IO tables, where the boundary of the regions matched the watershed boundaries.

Velazquez (2006) applied IO techniques to analyse inter-sectoral water relationships in Anadalusia, Spain. This work not only determined water consumption patterns of various sectors of the Andalusia economy, but it also outlined to what extent water may become a limiting factor in the growth of certain production sectors.

Sporri et al (2007) developed an IO model to predict the impacts of Thur River rehabilitation project on the local economy in Switzerland. The model was used to estimate changes in the local employment levels and local economic output resulting from the Government spending on the river rehabilitation works.

Guan and Hubacek (2007) utilised IO techniques to evaluate the inter-regional trade structure in China, and its effects on water consumption and pollution via virtual water flows. ‘Virtual water’ was defined by them as the water embedded in products and used in the whole production chain, and is traded between regions as well as exported.

Yang et al (2007) analysed the regional disparity of water consumption of different economic sectors, between South-east and North-east England. They utilised regional IO tables and extended IO model of water consumption for South-east and North-east of England.

2.2 Input Output Analysis in Australia

The first IO tables for Australia were developed by Burgess Cameron for the 1946-47 financial year. Although very different from the modern day tables that follow the international System of National Accounting (SNA93), the original work by Cameron nonetheless set the scene for IO compilation in Australia (Gretton, 2005).

The Australian IO tables are used by a large community of applied economics and policy researchers. According to Gretton (2005), a ‘*flagship use*’ of the Australian IO tables is in the production of the MONASH model, which is a dynamic computable general equilibrium (CGE) model of the Australian economy. The MONASH framework has also been disaggregated into eight sub-national state and territory regions.

The Australian Productivity Commission uses the national IO tables for analysing industry assistance policies as well as for measuring assistance afforded by tariff concessions in Australia (Gretton, 2005). A popular use of IO tables in Australia has been in carrying out regional economic studies, which has resulted in the development of several stand-alone regional IO models.

According to Powell and Snape (1992), the rise of economic literacy has been an important component in the evolution of policy development in Australia. By engaging policy makers in an analytical process that looks at their proposal within an economy-wide perspective, the quality of the debate has been improved. The Australian IO tables and economic models developed from these tables have played a key role in the evolution of policy (Powell and Snape, 1992).

2.2.1 Input Output Analysis and Australian Water Sector

The work by Lenzen and Foran (2001) is amongst the leaders in the application of IO techniques to water policy analysis. They carried out an IO analysis of Australian water usage. This work involved calculating water multipliers for 118 industry sectors of the Australian economy. Using this technique, Lenzen and Foran (2001) highlighted that if population and economic growth were to meet policy expectations, than the water required to deliver a unit of output across the Australian economy would have to reduce by a factor of two.

EconSearch (2003) used IO analysis to assess the regional economic impact of the Living Murray Initiative, which involved returning a proportion of river flows that were being used by irrigation, to the environment. The study looked at the impacts of this proposal on Coleambally and Berriquin regional economies.

Foran et al (2005) have utilised IO analysis techniques to develop a numerate triple bottom line account of the Australian economy for financial, social and environmental indicators. Water usage by the industry sectors is included in this work as one of the environmental indicators, along with energy use, greenhouse gas emissions and land disturbance.

More recently, Cox (2006) studied the impact of declining health of coastal waterways on the regional industries including commercial fishing, aquaculture and tourism. Impacts on the regional economy that would arise as a result of a reduction in these industries following a decline in ecosystem condition were calculated using regional IO models. This work highlighted that a 15 % decrease in aquaculture and fishing, and a 10 % decrease in tourism in Pumicestone (in Queensland) would result in a decrease in gross regional production of more than 2 % in Pumicestone.

IO analysis provides one of simplest methods to analyse economic activity in a production life-cycle context. According to Foran et al (2005), an IO model is politically and ideologically neutral, and does not incorporate any specific behavioural conditions for the individual, companies or the state.

Wassily Leontief (1986, cited in Foran et al, 2005) suggested that the IO Analysis can be applied to an economy as large as the entire world economy, or as small as the economy of a metropolitan area or even a single enterprise. The versatility of IO Analysis makes it a very useful tool for analysing the complex linkages within the economy, making it an ideal tool for water policy analysis.

3. Water Policy Crossroads

Sustainable water management of the future would have to be significantly different from the traditional water management paradigm that focused on meeting the demand for water by augmenting supply and disposing wastewater to prevent the spread of disease. Sustainable urban water systems need to focus on achieving a ‘closed loop’ through initiatives such as water recycling and reuse (Stenkes et al, 2004).

According to Radcliff (2007), the Ministry of Water Resources and Water Supply commissioned consultants Guttridge Haskins and Davey back in 1977 to develop ‘*Strategies Towards the Use of Reclaimed Water in Australia*’. Discussions on water reuse and its role in sustainable water resource management in Australia has therefore been on the agenda for over 30 years. Despite its long presence on the agendas of policy makers and scientific community, promulgation of water reuse in Australia has been a rather slow process.

According to Stenkes (2006), the progress of recycling at a decentralised and on-site scale within Australian metropolitan areas under schemes that are not owned by major water utilities is virtually non-existent. Simply inventing technical solutions and marketing them is not enough to advance sustainable water management in Australia. Substantial institutional change over a period of time is also crucial for this advancement (Stenkes, 2006). Institutional barriers between State-owned water utilities responsible for water supply and wastewater and Local Governments responsible for stormwater make this task extremely challenging. It is perhaps due to the embedded nature of the established institutions of water management, that planning and implementation of small-scale water recycling systems in metropolitan areas has been slow (Chanan, 2006).

According to Stenkes (2006), ‘Co-management’ of water reuse schemes by diverse groups could provide a useful alternative to current approach of large scale schemes, and could result in increased promulgation of water reuse. The term Co-management in context of natural resource management, is defined as *an arrangement whereby local people/organisations are given responsibility for decision-making about access to and use of natural resources…* (Tyler, 2006).

3.1 Co-Management of Urban Water and Local Governments

Local Government Authorities within metropolitan Australia provide an ideal candidate for advancing co-management of water in urban areas. According to Newman (2007), detailed knowledge of local natural processes is a necessary prerequisite for implementing appropriate water recycling initiatives. ‘*Such intimate knowledge of local soils, slopes, creeks, wetlands, as well as knowledge of the urban aspects of nature, i.e. open space, community gardens, street trees are ideally suited to the role of a local environmental scientist working in a local authority*’ (Newman, 2007).

Analysis of a number of water reuse projects in Europe concluded that a major benefit of water recycling is the production of alternative water resource ‘*near the point of use*’ (Lazarova et al, 2006). The European experience further confirms the advantage of local water reuse schemes, and highlights the potential for Local Government involvement in such schemes.

Authors’ experience in the urban water industry suggests that the traditional institutional framework has created a culture whereby Local Governments typically consider themselves as stormwater managers with little or no role in the wider urban water cycle management. In addition to stormwater management however, Local Government has a wide range of other legislative responsibilities such as the provision of sports and recreational facilities, land use planning, local economic development, community services as well as environmental health. A number of these functions are directly or indirectly related to the availability of reliable water supply.

In order to facilitate a policy shift amongst metropolitan Local Government Authorities to play a greater role in co-management of urban water cycle, there is a need for decision support tool. Such a tool should be able to demonstrate the benefits of

Local Government involvement/investment in managing the water cycle on the local economy.

3.2 Value of Non-potable Water Reuse

The CSIRO Water for Healthy Country Flagship aims to achieve '*tenfold increase in social, economics and environmental benefits from water use by 2025*'. A policy shift towards higher value water use will be a significant method to achieve such a goal. Within the urban water management context, this question would mean looking at various water uses and understanding their respective productivity value (Nosco Consulting, 2005).

For instance, looking at the value of water used for urban irrigation alone, one can undoubtedly conclude that it is vital for the survival of the Lifestyle Horticulture Industry. This industry includes businesses involved in the production of non-food horticulture products, such as ornamental plants, flowers and turf. It also incorporates a range of services including landscape design, sales of lifestyle horticulture products and services, construction and maintenance of parks, gardens and golf courses, and technical horticultural advice and information dissemination etcetera (Queensland DPIF, 2008). The lifestyle horticulture industry is currently experiencing significant downturn in parts of Australia due to the current drought and associated water restrictions.

Australian water policy makers commonly consider outdoor water use to be more discretionary than indoor water use. Consequently restrictions on outdoor water use are universally used by water utilities as an acceptable means to reduce demand at times of drought (Brennan et al, 2007). The Productivity Commission (2008) states that such prescriptive rationing by water utilities denies consumers an opportunity to choose the water use they value most. The national costs of water restrictions in 2005 have been calculated to be around $900 million (Productivity Commission, 2008).

Thorough understanding of the relevance of various industry sectors within a local economy can better equip water authorities to make sound policy decisions in the event of a drought. While economic impacts of drought imposed water restrictions on using potable water for outdoor irrigation has already been highlighted, economic analysis of investing in alternatives such as non-potable reuse schemes is now much warranted. Non-potable reuse has the potential to cater for 28% of the total water use in major cities, which represents the total non-household consumption (industry, commercial, local government) (WSAA, 2006). Ability to analyse costs and benefits associated with investment in non-potable reuse schemes, especially in context of productivity value of water would greatly benefit the urban water policy debate.

4. Methodology

The IO analysis provides an ideal methodology to answer the water policy questions discussed above. Firstly, IO models are capable of calculating productive value of water for various industry sectors, which corresponds to the amount of water required by the industry to produce $1 worth of output. Secondly, regional IO models can also be used to assess the impact of Local Government investment in decentralised water reuse schemes, on the local economy.

4.1 Regional IO Model for Kogarah

According to West and Bayne (2005), the application of IO Analysis in an economic impact study involves two main steps. The first is the acquisition or construction of a suitable regional transactions table and the transformation of the table into an appropriate model. And the second is the conversion of the issue to be analysed into a compatible form with the input-output equations, so that multipliers can be calculated and impacts can be estimated.

Yang et al (2007) discussed various non-survey techniques that can be used to derive regional IO tables by adjusting the national technical coefficients. Non-survey based methods are preferred due to expensive and time-consuming nature of the survey-based alternatives. Local Quotients approach is the most commonly used non-survey technique to generate regional IO tables. This approach involves adjusting the national technical coefficients from A Matrix, giving consideration to the potential for local demand to be satisfied locally.

As described by Miller and Blair (1985), for Kogarah local government area, a regional IO coefficient can be defined as:

$$a_{ij}^{Ko} = LQ_i^{Ko}(a_{ij}^{N})$$

where a_{ij}^{Ko} is the input-output technical coefficient for Kogarah, LQ_i^{Ko} is the location quotient that demonstrates the importance of sector i in Kogarah economy relative to the national economy, a_{ij}^{N} is the national technical coefficient.

Location Quotient measures the ability of a regional industry *i* to supply the demand for its product by other industries in the region, as well as the final demand of the region. Regional output data is required to calculate location quotient, however if this data is not available, measures such as employment, personal income earned, and value added can also be used (Miller and Blair, 1985).

Greater than one value of LQ_i indicates that sector i is more concentrated in the region than in the nation as a whole, and the regional coefficient is the as same as the nation. On the other hand if the LQ_i is less than one, it is assumed that the region cannot satisfy regional demand for outputs from sector i, and the national coefficients are adjusted by multiplying them by the LQ_i (Yang et al, 2007).

4.2 Productive Value of Water

According to Yang et al (2007), the fundamental assumption of the IO model is that the flows of sector *i* to *j* depend on the total output of sector *j*. Technical coefficient can be derived by dividing the inter-sectoral flows from *i* to $j(z_{ij})$ with total output of j (X_j).

$$a_{ij} = z_{ij} / X_j$$

where, a_{ij} is also called the direct input coefficient.

Extending the above concept to water consumption, by treating water as a primary input in the economic flows, direct water requirement coefficients f_j can be calculated by dividing the total amount of water directly consumed in the sector *j* with total inputs to that sector $x_{j.}$ (Yang et al, 2007) The f_j is measured in units Megalitres/$, and provide a good measure of productive value of water consumed by various industry sectors.

The direct water requirement coefficients only represent the first round effect of the interactions in an economy. Given that water is consumed both directly and indirectly, it is important to combine both these consumptions. The total water consumption multipliers can be derived by multiplying the direct water consumption coefficients f with Leontief Inverse $(1- A)^{-1}$ (Guan and Hubacek, 2007).

According to Guan and Hubacek (2007), the total amount of water consumed in any given sector to meet the demand, can be represented by

Total water consumption = $\hat{f}\ (I\text{-}A)^{-1}\ y$.

4.3 Impact on the Local Economy

According to West and Bayne (2005), decision to invest in an industry with view to stimulate the economy should carefully consider a range of issues and indicators, with 'key sector analysis' providing a good guide. For the purpose of this research, key sector analysis for Kogarah local government area will provide a means to analyse a case for or against local government investment in decentralised water reuse schemes, to enhance local economy.

A key sector is defined as the sector having above average (<1) backward linkage and forward linkage effects. However, an industry sector classified as a key sector in terms of its contributions to regional 'value added' may not necessarily be a key sector in terms of the 'water consumption'. It is assumed that investment in water reuse could be justified, if key sectors for both these variables correspond and availability of recycled water can be shown to benefit the industry sector that is also a key sector from value added perspective.

In conjunction with the key sector analysis, a hydro-economic IO table for Kogarah, as discussed by Guan and Hubacek (2007) will be used to demonstrate the dependence of each industry sector (key sector or otherwise) on availability of locally produced recycled water. This hydro-economic table will include a direct water consumption coefficient, f_{kj} which is defined by Guan and Hubacek (2007) as:

$f_{kj} = g_{kj} / X_j$

where g_{kj} is the amount of water supplied from the k water supply sectors consumed in the economic sector j, and x_j is the total input of the jth sector. Water supply sectors include potable water supply scheme as well as recycled water supply. For the purpose of this analysis it is assumed that all non-residential non-potable water uses will be using recycled water produced locally.

5. Conclusion

The feasibility of decentralised water reuse projects is driven by financial principles, which control the vital link of investment in such initiatives. Water utilities would generally be keen to provide recycled water and associated infrastructure only if, they are able to receive a return on their investment. It should be noted that before recycled water can be produced, significant infrastructure is required to treat and transport the water, to where it is needed.

The most commonly used evaluating methodology for water supply alternatives only goes as far as the economic bottom line (EBL) of the proponent water utility. According to Davis (2006), such analysis must also consider benefits to the wider economy that the utility supports, as well as future ratepayers. Davis (2006) argued that where recycled water is a more reliable source due to its location, its accessibility, its availability during droughts, or the risk that other sources may not be available in the future, the economic bottom line of a community might be better served by development of recycled water.

An important and commonly unacknowledged factor in the equation of water reuse is that of positive externalities. All water-recycling projects produce positive externalities, which are seldom accounted for while evaluating the benefits of a proposed reuse scheme. According to Sala and Serra (2004), it is important to understand and acknowledge these externalities, as they cover a wide range from public health, to landscape quality and resulting increase in property values, to improvement of habitats for local flora and fauna, and to restoration or recreation of ecosystems.

Nieto *et al*. (2001) (cited in Sala and Serra, 2004) measured some of these externalities in water recycling projects in the Costa Brava, Spain. Their work included the estimation of the reduction in nutrient discharges to the environment, which account for 25 tons of nitrogen and 6 tons of phosphorus every year. Reduction in nutrient load in turn has resulted in a marked improvement in the microbiological quality of the bathing waters of the beach, at the mouth of the Muga river, in Castelló d'Empúries. This work strengthens the need for determination and measurement of positive externalities for all water recycling projects, which can provide a more comprehensive view of the benefits brought by such projects.

As previously discussed, given the wide range of services that Local Government Authorities provide to their local communities, they sit in a unique position to run decentralised reuse operations. Whilst environmental benefits of water reuse have been well researched and published over the last decade, limited effort has gone towards socio-economic aspects of water reuse. The current research aims to use IO Analysis as a methodology to highlight the socio-economic benefits of water reuse, while presenting a case for greater local government involvement in the same.

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