

Successful wastewater reuse scheme and sustainable development: a case study in Adelaide

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Abstract

Freshwater availability to meet the growing needs of humankind has raised serious concerns in the recent past. Two immediate responses to counter this challenge are efficient allocation of the scarce resources, and development and use of alternative sources of water. While 'water markets' are seen as a means to achieve efficient allocation of the scarce resources, treated wastewater and low-quality water are now considered as potential sources of water to supplement the freshwater supplies. However, the latter option, that is use of reclaimed water as an alternative, imposes concerns regarding its suitability to sustain development. This is because of various issues related to wastewater usage and application. At the same time, it is also true that a successful and well-planned reuse scheme can help achieve sustainability as evidenced in some isolated cases around the world. In line with this, the current paper adopts a case-study approach to demonstrate how a successful reuse scheme in Adelaide, South Australia, has contributed to the sustainable development of the region. The paper looks into the socio-economic and environmental dimensions of sustainability and arrives at a conclusion that properly planned and managed reuse schemes backed with effective regulatory and policy measures can lead to sustainable development.

Introduction

Freshwater availability to meet the growing needs of humankind has raised serious concerns in the recent past. The pressure on existing freshwater resources has increased because of rapid urbanization and industrialization. In addition, pollution caused by discharge of growing volumes of wastewater into the receiving waters has further reduced the availability of freshwater resources. Thus, freshwater has become a limiting factor. According to a United Nations World Water Development Report (2006), 'providing the water needed to feed a growing population and balancing this with all the other demands on water, is one of the great challenges of this century'. Therefore, efficient allocation of the scarce resource and finding additional/alternative sources of supply to address perceived new demands are the challenges being faced by water planners and policy makers. Thus, our actions to counter this challenge should be sustainable without depleting natural resources or harming the environment. In such a situation, two immediate

responses emerge to counter the water scarcity challenges: (i) Reallocating available supplies through water marketing strategies (Dinar *et al.* 1997; Easter *et al.* 1999; Bjornlund 2003) and (ii) source substitution (Hespanhol 1997; Cullen 2004). Water marketing strategies improve the efficiency of water use and can be a path to efficient allocation of the scarce resource (Simpson 1994) and, 'source substitution appears to be the most suitable alternative to satisfy less restrictive uses, thus allowing high quality waters to be used for domestic supply' (Hespanhol 1997). This paper deals with the later option, which is source substitution to augment freshwater supplies.

In the event of water scarcity and its associated problems, concepts such as water reclamation and recycling are considered as key components of water and wastewater management policies around the world. Wastewater (treated) is now considered by some as a new and reliable water source to supplement limited freshwater resources, without compromising public health (Asano 2001; Bahri 2001; Angelakis *et al.* cited in Abu Madi *et al.* 2003; Murni *et al.* 2004). Nevertheless, due to various

issues related to wastewater usage and application, implementing sustainable wastewater schemes has raised concerns in the past. Conflicting agendas among water agencies; addressing water rights issues; dealing with opponents to recycling/reuse; modifying existing regulations; and acquiring funding are the main challenges encountered during the successful development of reuse schemes (Kasower 1998; Ritchie *et al.* 1998; Mills 2000; Asano 2001; all cited in Haddad 2002; Murni *et al.* 2004). However, in some isolated cases, successful and well-planned reuse schemes have contributed to sustainability (Dimitriadis 2005).

Against this background, this paper adopts a case-study approach and illustrates how a successful reuse scheme in Adelaide, South Australia, has contributed to the sustainable development of the region. It looks into the socio-economic and environmental dimensions of sustainability and examines how collective efforts and effectively designed partnerships between key stakeholders, backed up with effective regulatory and policy measures, can lead to development of a successful reuse scheme ultimately resulting in the sustainable development of the region.

Reclaimed water use in Australia and South Australia

Australia, the driest inhabited continent on earth, is currently experiencing the highest amount of pressure on its water resources. The agriculture sector is the major consumer of freshwater supplies and irrigated agriculture accounts for around 67% of Australia's total water usage (Australian Bureau of Statistics 2004). Hence, 'substitution of water used in agriculture and urban irrigation with reclaimed water will free up water and help make appropriate allocations to the environment, thus ensuring good environmental condition for stressed water supplies' (Hamilton *et al.* 2005, p. 185). In line with this thought, over the past decade, significant reforms in water and wastewater policies have occurred in Australia (Radcliffe 2004). Issues such as environmental health, sustainability and water availability have taken centre stage, resulting in increased use of reclaimed water in agriculture and urban irrigation. Because of these developments, Australia is today a world leader in the use of treated wastewater (Dimitriadis 2005). According to the Australian Bureau of Statistics (2004) data for the period 2000–2001, around 27.8% of the total volume of effluent produced (1837.2 GL) (in SI system, 1 GL=1 Gigalitre=1 000 000 m³) was reclaimed. However, due to differences in definitions, the estimates of reclaimed water use sometimes vary considerably (Hamilton *et al.* 2005). In South Australia,

which is the study state around 18.7% of the total volume of effluent produced is reclaimed (Australian Bureau of Statistics 2004). The state also has the highest level of wastewater reuse per capita in the country (Dimitriadis 2005). Adelaide metropolitan area, which has an annual flow of around 77 200 ML (1 ML=1000 m³) from three treatment plants, reclaims around 16%. However, with respect to the Bolivar wastewater treatment plant, which is associated with the scheme, under study 21% of the annual flow is reclaimed (Radcliffe 2004).

Overview of Virginia Pipeline Scheme (VPS)

The VPS is catering to the irrigation needs of the growers in the township of Virginia, Adelaide, South Australia. The region is described as South Australia's 'Veggie Bowl' because of its reputation to deliver high-quality horticultural produce to local and interstate markets.

The scheme is a co-operative undertaking of the Virginia Irrigation Association (VIA) – representing market gardeners and other irrigators; SA Water and Water Reticulation Systems Virginia (WRSV) – a private company. It supplies highly treated reclaimed water to approximately 250 growers operating within an area of 200 km² often described as the 'Virginia triangle'. The main elements of the scheme consist of a treatment plant at Bolivar, storage reservoir, and 150 km of distribution pipe work. Figure 1 provides the schematic layout of the scheme and its distribution network.

Historically, the Virginia horticulture industry relied on the ground water resources for irrigation water supply. However, as a result of (over)using the groundwater resources for irrigating the horticultural crops, the water levels in the aquifers declined and groundwater became a really scarce resource. The groundwater resource has provided about 18 000 ML/year, which is beyond the sustainable limits (Kracman *et al.* 2001). The estimated sustainable limit is around 8000–10 000 ML/year (Northern Adelaide and Barossa Catchment Water Management Board 2000). As a result, several growers used Class C reclaimed water to irrigate the market gardens by pumping from the Bolivar wastewater treatment plant out-fall channel with the help of their own reticulation pipelines. Table 1 gives a classification of reclaimed water for use in South Australia.

The growers, thus, had recognized the potential of this new source of water to provide a secure supply for irrigating their crop lands. This realization by the growers, accompanied by the social, economic and the environmental drivers, led to the development of the VPS (Thomas 2006). The scheme is built on the build-

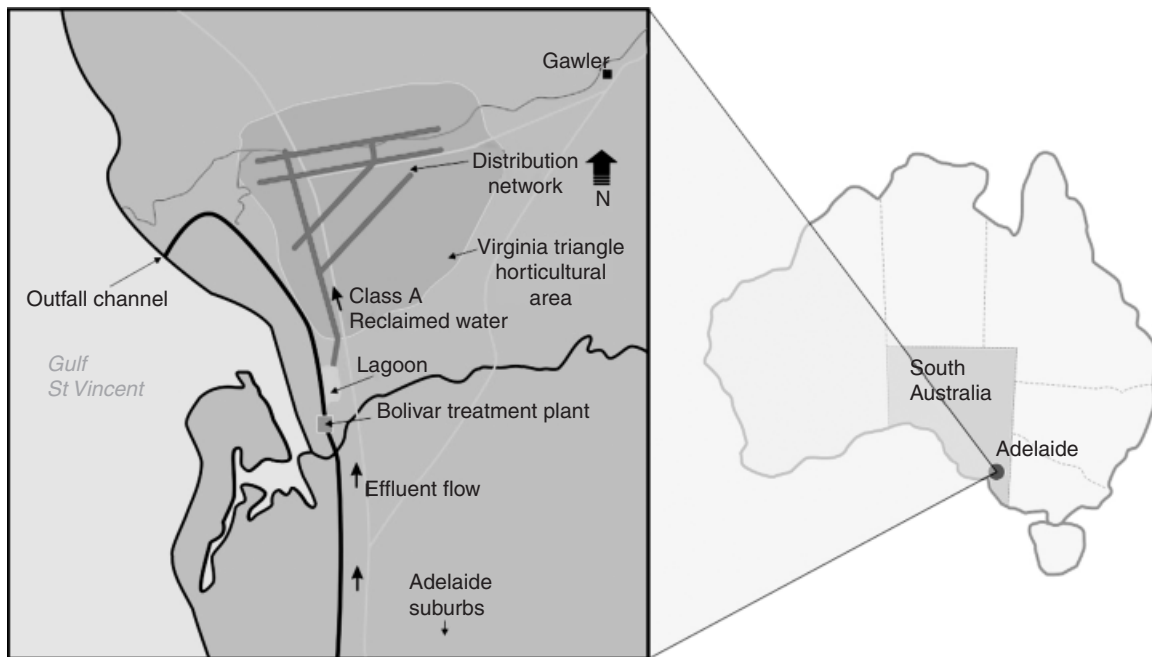


Fig. 1. Layout of the Virginia Pipeline Scheme and its distribution network. Source: Modified from Radcliffe (2004). Note: Figure not to scale.

Table 1 Classification of reclaimed water for use in South Australia in comparison with drinking water standards

Class	Typical treatment process	Microbiological, chemical, and physical criteria	Uses	Drinking water parameters
Class A	Full secondary plus tertiary filtration plus disinfection. Coagulation may be required to meet water quality requirements	< 10 (<i>E. coli</i> /100 mL); ≤ 2NTU (Turbidity); < 20 mg/L (BOD); Chemical content to match the use	Residential nonpotable; Municipal use with public access; Unrestricted crop irrigation	Nil (<i>E. coli</i> /100 mL) ≤ 1NTU (Turbidity) < 5 mg/L (BOD)
Class B	Full secondary plus disinfection	< 100 (<i>E. coli</i> /100 mL); < 20 mg/L (BOD); < 30 mg/L (SS); Chemical content to match the use	Municipal use with restricted access; Restricted crop irrigation; Irrigation of pasture and fodder for fodder animals	
Class C	Primary sedimentation plus lagooning or full secondary (disinfection if required to meet microbial criteria only)	< 1000 (<i>E. coli</i> /100 mL); < 20 mg/L (BOD); < 30 mg/L (SS); Chemical content to match the use	Municipal use with restricted access; Restricted crop irrigation; Irrigation of pasture and fodder for fodder animals	
Class D	Primary sedimentation plus lagooning or full secondary	< 10 000 (<i>E. coli</i> /100 mL); Chemical content to match the use	Restricted crop irrigation; Irrigation for turf production; Silviculture and nonfood chain aquaculture	

Source: South Australian Reclaimed Water Guidelines (treated effluent), 1999 and World Health Organisation (WHO), 2004. NTU, nephelometric turbidity unit; BOD, biochemical oxygen demand; SS, suspended solids; *E. coli*; *Escherichia coli*.

operate-transfer (BOT) model and is the largest of its type in the whole of Australia. As part of its Environment Improvement Programme (EIP), SA Water constructed a filtration/disinfection plant (DAFF) worth A\$30 million to treat lagoon effluent from the Bolivar wastewater treatment plant. This resulted in production of Class A,

reclaimed water that, instead of being disposed off to the receiving waters, could be used for irrigation of market gardens. Based on the parameters cited in Table 1 for Class A water and drinking water, it is evident that the water in this case is being treated to a very high level and is better than many polluted river sources.

Realizing the potential of this valuable resource, the WRSV, on behalf of the VIA and with financial assistance from SA Water and the Federal government, constructed an extensive distribution system to supply treated wastewater for irrigating the crop lands in Virginia. Thus, the scheme was finally commissioned in 1999, which was largely possible due to the collective efforts and effective partnerships between key stakeholders. Since then, the scheme is successfully operating and has immensely contributed to the sustainable development of the region.

Applying the principles of sustainable development

In recent times, 'sustainability' and 'sustainable development' has become the catchphrase among politicians, bureaucrats, academics, and researchers. Nevertheless, the concept tends to be rather vague and confusing to be used in a wide variety of contexts and without empirical validation (Copus & Crabtree 1996). As defined in the Brundtland report sustainable development is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development 1987). This implies that sustainable development is any development that meets environmental, economic and social objectives simultaneously.

In line with this, this paper discusses how a successful water reuse scheme (the VPS) has contributed to the sustainable development of the region in which it is operating (Virginia region). But, first, a look at the partnerships created for implementing the scheme.

Implementation of the VPS was possible mostly due to enhanced participation and effectively designed partnerships between the key stakeholders through contractual agreements. Figure 2 depicts the contractual agreements signed by the stakeholders involved in the scheme before the commissioning.

As a part of the contractual agreement, this scheme is built under the BOT model. In a BOT project, 'a private company is given concession to build and operate a facility that would normally be built and operated by the government' (UNIDO 2006 cited in Braadbaart 2005). Under the BOT form of partnership, capital investment, designing and building and operation of the scheme is the responsibility of the private sector while the responsibility of setting performance standards, asset ownership, user fee collection, and oversight of performance and fees rests with the public agencies. Likewise, in this case a private consortium (WRSV) is responsible for building the scheme and in charge of its operations until the whole scheme is returned to the ownership of SA Water in 2019.

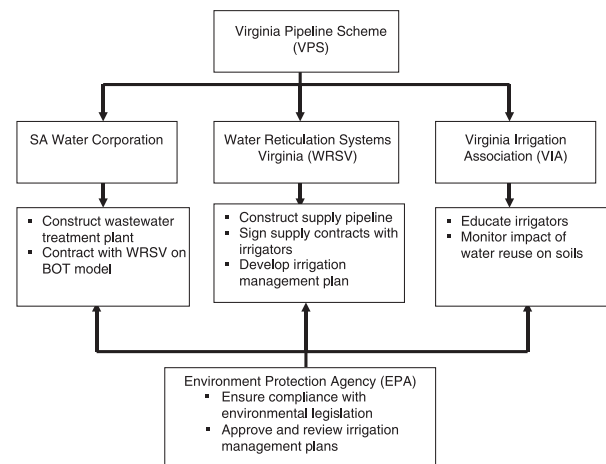


Fig. 2. Contractual agreements between key stakeholders in VPS. BOT, build-operate-transfer; SA, South Australia.

The SA Water (public agency) is responsible for setting performance standards, asset ownership, user fee collection and oversight of performance and fees, while the WRSV (private company) is responsible for capital investment, designing and building and operation of the scheme. However, SA Water and Federal government have contributed some portion of the initial investment in this case.

To ensure that the irrigation of the agricultural land is sustainable, an Irrigation Management Plan (IMP) is developed. The responsibility of reporting deviations, if any, from the plan is assigned to WRSV. The Environment Protection Agency (EPA) is responsible for ensuring that all environmental legislation is complied with and for approving and reviewing the IMPs on an annual basis. The VIA is responsible for educating the growers in relation to water reuse. Through this programme, the VIA educates the irrigators about the impact of the enhanced nutrient levels on soils and natural groundwater by use of reclaimed water. It also closely monitors the effects of the reclaimed water on the soils. Above all, South Australia has a favourable regulatory and policy framework for wastewater reuse. The government policy to phase out all sewerage discharges to the marine environment where it is economically and environmentally sustainable (Thiyagarajah 2005) and inclusion of reclaimed water in the South Australian Government's State Water Plan 2000 demonstrates the State's commitment to recycled wastewater projects. Thus, with sound policies, proper planning and management, sufficient financial commitments, and public awareness, support and participation, the VPS is operating successfully since it is commissioning and has resulted in the economic, social, and environmental sustainability of the region.

Although the concept of sustainability has become popular in recent years, it is interpreted differently by specialists in different disciplines. For example, social scientists say a lot about social sustainability; economists deal with economic sustainability; and environmentalists deal with environmental sustainability. However, a holistic approach to understand sustainability is to deal with all the three dimensions (Sullivan 2003). In the present context, we use a definition that best relates to the agriculture use of reclaimed water. This definition states that, 'sustainability is the ability of an agro-ecosystem to maintain productivity in the face of stress or shock' (Conway 1997 cited in Abdel-Dayem 1999). The definition is appropriate as it considers an agro-ecosystem that comprises of the land, plants, animals, environment and the people who husband them in order to produce food and other agricultural products. Thus, this paper adopts a systems approach wherein economic profit, social benefits to the farm family and community, and environmental conservation are considered the measures of economic, social, and environmental sustainability respectively. Table 2 is a sustainability matrix for the Virginia region developed based on the growers' perceptions and field observations.

Economic sustainability

A widely accepted definition of economic sustainability is maintenance of capital, or keeping capital intact (Goodland 2002). However, in the present context, as we are dealing with use of reclaimed water for agriculture purposes, factors such as production volumes, purchase of fertilizers, land values, and markets for the produce grown using reclaimed water are considered as the sustainability indicators (Table 2). It is clear from the table that the growers were very positive about the growth in the production volumes as the inception of the scheme. Although exact production figures are unavailable, the

Table 2 Socio-economic and environmental sustainability matrix for Virginia region

Economic sustainability (++)	Social sustainability (++)	Environmental sustainability (\pm)
Production volumes (++)	The social capital (++)	Groundwater mining (++)
Purchase of off-farm fertilizers (\pm)	Farming income (++)	Marine environment (++)
Market value of land (++)	Job opportunities (++)	Soil quality (\pm)
Markets for produce (++)	Community cohesion (++)	Health concerns (\pm)

Source: Field survey.

++, more sustainable; \pm , less sustainable.

relative resource use data available indicate an increase in the delivery of water to the region. In 1999–2000, 6000 ML of reclaimed water was used, which increased to 12 100 ML in 2004/2005 (Thomas 2006), which means an increase of 6100 ML over a period of 5 years. This increase is mainly due to the growth of the horticultural industry in the region, which can broadly be divided into two groups – glasshouse-based enterprises and broad acre vegetable concerns. The area under glasshouse industry, which supports approximately 600 growers, is expanding at a rate of 8–10%/year within the Northern Adelaide Plains (Northern Adelaide and Barossa Catchment Water Management Board 2000). As the horticulture industry continues to expand, the scheme managers expect that reclaimed water use will further increase. According to South Australian Centre for Economic Studies, currently about 3500–4000 ha are under production in the Northern Adelaide Plains but with expanded irrigation a further 4500–9000 ha could be used for horticulture (cited in Northern Adelaide and Barossa Catchment Water Management Board 2000).

Regarding the second indicator, growers agreed that the nutrients in reclaimed water provide fertilizer value in crop production and thus curtail the purchase of off-farm fertilizers. However, excessive use of the resource in question might sometimes result in excessive vegetative growth, delayed or uneven maturity, or reduced quality, which is not sustainable, hence indicated by (\pm) in the Table 2. There is no doubt that water allocations add value to the land, which means that land with water has more market value than the land without water. In the present case, the growers expressed that a good land for horticulture without water and improvements costs A\$15 000/ha, which shoots up to around A\$30 000/ha when a water allocation is supplied with the land (2003/2004 prices). They further opined that 'reclaimed water has the same influence on land values as groundwater' and therefore in terms of market value, the reclaimed water allocations have benefited the lands in the region.

Market for the produce grown using reclaimed water is one of the areas of concern while implementing any water reuse scheme. In this case, the growers reported that the acceptance level of the produce grown with reclaimed water was encouraging at all levels of the retail chain. This was achieved through communication campaigns carried out at different levels to train and educate the key stakeholders – industry, retailers, and the public. In addition, the wholesalers were kept informed of the development of the scheme and reassured that product quality would not be compromised. Moreover, endorsement of the scheme by the South Australia Department of Human Services and the EPA was also helpful in building up the confidence level of the consumers

regarding product quality. Currently, with domestic market being well supplied with fresh vegetables and increased water supplies leading to increased production, there is scope for development of export markets in the area.

Social sustainability

Social sustainability means maintaining social capital. According to Goodland (2002), 'social capital is investments and services that create the basic framework for society. It lowers the cost of working together and facilitates cooperation'. In this case, despite the varied ethnic and cultural backgrounds of the growers associated with the VPS and different stakeholders involved in partnerships, the scheme has been operating successfully as the commissioning. This in itself demonstrates the presence of high social capital within the community.

Further, trust is one of the most frequently encountered elements in definitions of social capital (Hutchinson & Vidal 2004). Therefore, the study attempted to examine the level of trust among the irrigators and also the trust in the agencies associated with the scheme. A series of likert scale items were used to measure irrigator's perception about trust. According to Fig. 3, it is evident that the level of trust within the community is high. Three statements were proposed to measure trust among the community

while the irrigators' level of trust in four associated agencies was measured using a 10-point Likert scale where 10 indicated 'strongly agree', 0 indicate 'strongly disagree' and 5 implied 'indifferent' (Fig. 3). Similarly, irrigators' trust in the associated agencies to deliver their responsibilities is also high. However, trust in EPA and department of health services was relatively low because respondents were not fully aware of the responsibilities of these agencies in relation to operation of the scheme.

In addition, the families in the region derive most of their income from activities dependent on irrigation (horticulture industry), indicating that this industry supports almost all the families in the community. Moreover, with the industry bound to expand in coming years, there is no doubt more people will be taking up farming. The commissioning of the scheme has resulted in expansion of the horticulture industry, which in turn has resulted in the creation of more jobs for the region. Horticulture being a labour-intensive industry has resulted in increased labour force for the agricultural sector in the region. The ABS census data from 1996 and 2001 shows a 7.5% increase in the labour force. Further, more jobs will be created as downstream opportunities in the packing, processing, and marketing industries. This highlights a strong link between increased horticultural production and job opportunities.

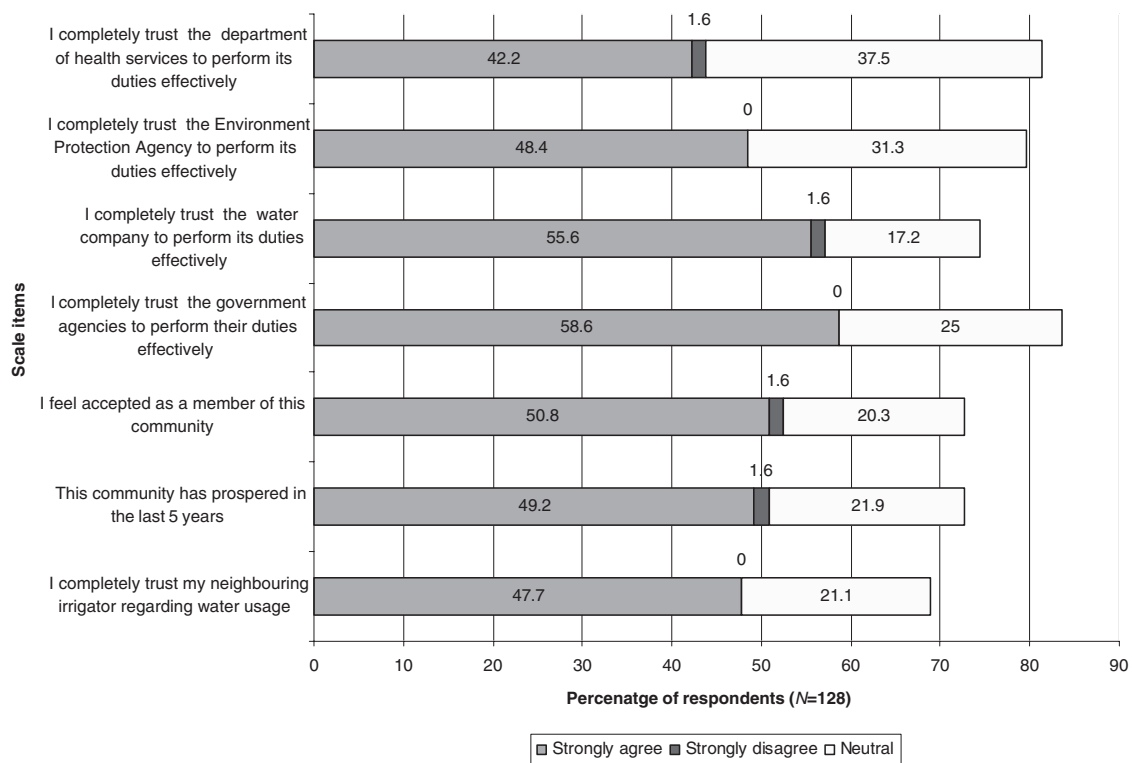


Fig. 3. Irrigators' perception about trust in the community and associated agencies.

Good communication, trust, mutual support (Sullivan 2003), and community cohesiveness (Goodland 2002) are central to social sustainability. A general argument regarding collective action is that division of irrigators by cultural and/or other social differences affects their capacity to communicate with one another (Lowdermilk, Clyma & Carly 1975; Merrey & Wolf 1986 both cited in Tang 1992). In the present case, it was observed that the irrigators associated with the irrigation scheme represented different ethnic groups – Vietnamese, Cambodian, Greek, Italian, and Australian communities. Despite such variations in the cultural backgrounds, the irrigators have come together and found a solution to deal with the problem of groundwater depletion in the region. Today, this scheme which is the result of a high degree of networking between the local community and other partners, is a great success. While contradicting previous studies, the findings of this study suggest that relatively heterogeneous community groups can be more effective at provision of irrigation services (Kurian & Dietz 2005) and hence promoting social sustainability.

Environmental sustainability

Groundwater has been the predominant water resource for the Virginia horticultural region until the development of the VPS. This resource has provided about 18 000 ML/year, which is beyond sustainable limits (Kracman *et al.* 2001). As a result of overuse, the groundwater resources in the region were seriously depleted, ultimately resulting in increased bore and pumping costs, and the quality of the groundwater was adversely affected by incursions from adjacent saline aquifers (Thomas 2006). However, with the commissioning of the VPS, use of groundwater in the area has been reduced, which is evidenced by increased water levels of the two aquifers [Tertiary 1 (T1) and Tertiary 2 (T2)] beneath the region.

Discharge of effluents degrades the quality of the freshwater and, hence, has a negative impact on the water's beneficial uses, and the health of its aquatic ecosystem. The Bolivar Wastewater Treatment Plant which is the main source of reclaimed water, discharges an average 40 000 ML of sewage effluent per year into the Gulf (Kracman *et al.* 2001). Therefore, by using reclaimed water from the Bolivar, the VPS has decreased the volume of nutrient-rich-treated effluent entering St. Vincent Gulf. Currently, the scheme has reduced the outfall by around 30% as 12 100 ML of flow from the Bolivar plant is used for irrigation. Given the scheme capacity of 23 000 ML, the outfall can be further reduced to more than 50%. Thus, the scheme has helped improve the marine environment (Marks *et al.* 1998) and has reduced

the impact of the nutrients discharged on the Gulf's sea grass.

Use of reclaimed water in agriculture might result in adverse environmental hazards. Soil salinization is the most serious potential environmental hazard as a high sodium content in the irrigation water may reduce soil permeability and may create an unsustainable environment for plant growth (Abdel-Dayem 1999). Therefore, in the present case, to ensure that irrigation applied to the soil cover does not affect the soil physical and chemical properties, an IMP is developed. The plan includes and addresses the following specific items: water balance; subsurface drainage and overall irrigation strategy. However, the growers still have some concerns about the impact of reclaimed water on the soil quality in the long run, which is indicated as (\pm) in the Table 2. In addition, from a health point of view, pathogenic micro- and macro-organisms present in the reclaimed water are the contaminants of greatest concern as in every reuse scheme, there is some risk of human exposure to these contaminants. In case of the VPS, training and awareness programmes carried out by the VIA, an agreement to pump reclaimed water in lilac pipes and display of sign boards to warn about the use of reclaimed water (see Fig. 4) has taken care of the health hazards to a large extent. However, a few growers are still sceptical about the potential health hazards from the use of reclaimed water.

From Table 2 it is clear that the scheme has been able to achieve a high level of economic and social sustainability, while, regarding the environmental sustainability, there is still scope for improvement. However, considering the overall benefits from the scheme, there is no doubt that it has contributed to the sustainable development of the region.



Fig. 4. Lilac pipes and sign board display used in the Virginia Pipeline Scheme.

Conclusions

Freshwater scarcity and its associated problems are acknowledged worldwide. On the other hand, use of reclaimed water or low-quality water for potable and nonpotable use has emerged as an alternative option to augment continuously depleting freshwater supplies. However, regarding the latter option, use of this valuable resource imposes concerns regarding its suitability to sustain development because of various issues related to wastewater usage and application. But as evidenced in the case of the VPS, it can be said that by providing knowledge and information on the 'current best practices' and communicating this information in a form that is understandable to the key stakeholder groups, any reuse scheme can be instrumental in achieving sustainability with its economic, social, and environmental dimensions. Therefore, with sound policies, proper planning and management, sufficient financial commitments, and public awareness, support and participation, it is possible to attain sustainability. Here are a few suggestions from the VPS experience for development of reclaimed water irrigation schemes in the future:

- (1) Location-specific guide lines for wastewater use and management should be prepared.
- (2) Awareness programmes regarding the legal, social, economic, environmental and health issues related to wastewater should target all key stakeholders.
- (3) Private sector should play a key role in wastewater treatment and management.
- (4) Enhanced community participation is crucial in achieving sustainability.

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References

- Abdel-Dayem, S. (1999) *A framework for sustainable use of low quality water in irrigation*. Paper presented at the International Commission on Irrigation and Drainage conference on Water for agriculture in the new millennium: sustainable use for poor quality water (Special session), 11–19 September, Spain.
- Abu Madi, M., Braadbaart, O., Al-Sa'ed, R. and Alaerts, G. (2003) Willingness of Farmers to Pay for Reclaimed Waste-water in Jordan and Tunisia. *Water Sci Technol Water Supply*, **3** (4), 115–122.
- Asano, T. (2001) *Water from (waste) water – the dependable water resource*. Paper presented at the 11th Stockholm Water Symposium, 12–18 August, Stockholm, Sweden.
- Australian Bureau of Statistics. (2004) Water account for Australia 2000–01. Report no. 4610.0. ABS, Commonwealth of Australia [online]. <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4610.0Main+Features12000-01?OpenDocument> [Last accessed 23 May 2006].
- Bahri, A. (2001) Irrigation with reclaimed water in Tunisia and in Middle Eastern countries [online]. <http://211.147.14.17/lianmeng/21cnwater/eng-art/2001/ajs.htm> [accessed 3 November 2004].
- Bjornlund, H. (2003) Efficient Water Market Mechanisms to Cope with Water Scarcity. *Water Resour Dev*, **19** (4), 553–567.
- Braadbaart, O. (2005) Privatizing Water and Wastewater in Developing Countries: Assessing the 1990s, Experiments. *Water Policy*, **7**, 329–344.
- Copus, A.K. and Crabtree, J.R. (1996) Indicators of Socio-Economic Sustainability: An Application to Remote Rural Scotland. *J Rural Stud*, **12** (1), 41–54.
- Cullen, P. (2004) *Water challenges for South Australia in the 21st Century*. Adelaide Thinker in Residence, Department of the Premier and cabinet, South Australia. 11 pp.
- Dimitriadis, S. (2005) *Issues encountered in advancing Australia's water recycling schemes*. Research Brief, No. 2, Department of Parliamentary Services, Parliament of Australia, 2005–2006.
- Dinar, A., Rosegrant, W.M. and Meinzen-Dick, R. (1997) *Water allocation mechanisms: principles and examples*. Policy Research Working Paper No. 1779, The World Bank, Washington DC.
- Easter, W.K., Rosegrant, W.M. and Dinar, A. (1999) Formal and Informal Markets for Water: Institutions, Performance, and Constraints. *The World Bank Res Observer*, **14** (1), 99–116.
- Goodland, R. (2002) Sustainability: Human, Social, Economic and Environmental. In Timmerman, P. (ed). *Social and Economic Dimensions of Global Environmental Change, Encyclopedia of Global Environmental Change*. Vol. 5, pp. 489–491. John Wiley and Sons Ltd, New York.
- Haddad, B.M. (2002) Monterey County Water Recycling Project: Institutional Study. *J Water Resour Planning Manage*, **128** (4), 280–287.
- Hamilton, A.J., et al. (2005) Position of the Australian Horticultural Industry with Respect to the Use of Reclaimed Water. *Agri Water Manage*, **71** (3), 181–209.
- Hespanhol, I. (1997) Wastewater As A Resource. In Helmer, R. and Hespanhol, I. (eds). *Water Pollution Control: A Guide to Use of Water Quality Management Principles*, pp. 91–124. Published by E. and F. Spon, London, on behalf of WHO/UNEP.
- Hutchinson, J. and Vidal, A.C. (2004) Using Social Capital to Help Integrate Planning Theory, Research, and Practice. *J. Am. Planning Assoc.*, **70** (2), 142–192.
- Kracman, B., Martin, R. and Sztajnbock, P. (2001) The Virginia Pipeline: Australia's Largest Water Recycling Project. *Water Sci Technol*, **43** (1), 35–42.

- Kurian, M. and Dietz, T. (2005) *How pro-poor are participatory watershed management projects? – An Indian case study.* Research Report 92. International Water Management Institute, Colombo, Sri Lanka.
- Murni, Po., Juliane, K. and Nancarrow, B.E. (2004) *Literature Review of Factors Influencing Public Perceptions of Water Reuse. Australian Water Conservation and Reuse Research Program.* CSIRO, Land and Water, Victoria, Australia.
- Northern Adelaide and Barossa Catchment Water Management Board. (2000) *Catchment Water Management Plan – Vol. 3: Water Allocation Plan.* NABCWMB, Salisbury, Adelaide.
- Radcliffe, J.C. (2004) *Water Recycling in Australia. Review Report.* Australian Academy of Technological Sciences and Engineering, Victoria, Australia.
- Simpson, L.D. (1994) Conditions for Successful Water Marketing. In Le Moigne, G. et al. (eds). *Water Policy and Water Markets – Selected Papers and Proceedings from the World Bank's Ninth Annual Irrigation and Drainage Seminar, Annapolis, MD, 8–10 December, 1992*, Vol. 1, pp. 97–102. The World Bank, Washington, DC.
- Sullivan, P. (2003) *Fundamentals of Sustainable Agriculture: Applying the Principles of Sustainable Farming.* National Center for Appropriate Technology, Fayetteville, AR.
- Tang, S.Y. (1992) *Institutions and Collective Action: Self-Governance in Irrigation.* ICS press, San Francisco.
- Thiyagarajah, R.A. (2005) Sustainable wastewater reuse through private sector participation – The Adelaide experience. <http://www.adb.org/Documents/Events/2005/Sanitation-Wastewater-Management/paper-thiyagarajah.pdf> [accessed 28 March 2006]
- Thomas, R. (2006) Reuse in South Australia. In Steven, D. (ed). *Growing Crops with Reclaimed Wastewater*, pp. 6–14. CSIRO Publishing, Victoria, Australia.
- United Nations World Water Development Report. (2006) *Water a Shared Responsibility.* Published jointly by the UNESCO/Berghahn Books, Paris.
- World Health Organization. (2004) *Guidelines for Drinking Water Quality.* Vol. 1. (3rd edn). WHO, Geneva.
- World Commission on Environment and Development. (1987) *Our Common Future.* United Nations. Oxford University Press, Oxford.