Desalination and Water Treatment
www.deswater.com
32 (2011) 297–306
August
1944-3994 / 1944-3986 © 2011 Desalination Publications. All rights reserved.
doi: 10.5004/dwt.2011.2714

SWOT analysis to assist identification of the critical factors for the successful implementation of water reuse schemes

B. Mainali[a], H.H. Ngo[a]*, W.S. Guo[a], T.T.N. Pham[a], X.C. Wang[b], A. Johnston[c]

[a]*Faculty of Engineering and Information Technology, University of Technology, Sydney, NSW 2007, Australia*
Tel. +61 (2) 95141693; Fax +61 (2) 9514-2633; email: h.ngo@uts.edu.au
[b]*Xi'an University of Architecture and Technology, Xi'an, Shaanxi, 710055, China*
[c]*Faculty of Engineering and Information Technologies, University of Sydney, NSW 2008*

Received 28 July 2010; Accepted in revised form 13 November 2010

ABSTRACT

The reuse of urban wastewater has been recognised as an important alternative source of water and is a key aspect of sustainable water policy. As it is a promising innovation, a number of direct and indirect water reuse projects have been instigated and proposed, both nationally and internationally. However there is some uncertainty regarding the effectiveness and impact of these water reuse schemes (WRS). This study investigates the applicability of Strengths, Weaknesses, Opportunities, and Threats (SWOT) as an analysis tool for formulating the critical factors in terms of the implementation of water reuse schemes. Basically, this work adopts an existing multiple case study design method and makes use of SWOT to analyse all critical factors for each selected water reuse scheme. The strengths and weaknesses of successful and unsuccessful WRS are analysed followed by an assessment of the corresponding external opportunities and threats.. On this basis, the critical factors considered for the successful implementation of the WRS are identified. A qualitative investigation using SWOT analysis has therefore been successfully implemented.

Keywords: Water reuse; Direct and indirect reuse; Implementation schemes; Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis; Urban water management

1. Introduction

Currently, the increasing stress on freshwater resources is of major concern. The concept of beneficial use of treated wastewater has therefore rapidly become an imperative for water agencies around the world [1,2]. This can help alleviate the pressure on existing water supplies whilst preventing water sources from being polluted. The other benefits include, recovery of nutrients for agriculture, augmentation of river flow, savings in wastewater treatment, enhancing groundwater recharge, and sustainability of water resource management [3]. Recycling of urban wastewater has therefore been recognised as an important source and a key aspect of sustainable water management.

Numerous direct and indirect reuse projects have been instigated around the world. Some have been successful; others that have been controversial in approach have often been completely rejected by the general public and hence unsuccessful. Singapore, Israel, Namibia, the United States (US), Australia and many European countries have examples where successful direct and indirect

* Corresponding author.

Presented at the Third International Conference on Challenges in Environmental Science & Engineering, CESE-2010
26 September – 1 October 2010, The Sebel, Cairns, Queensland, Australia

reuse projects have been implemented [2,4]. However, there are also some failures in the United States, Australia and some European countries [2,5,6].

Many water reuse surveys have come to the conclusion that the best water reuse projects, in terms of economic viability and public acceptance, are those that substitute reclaimed water for potable water in irrigation, environmental restoration, cleaning, toilet flushing, and industrial uses [2]. Critical factors for the successful implementation of water reuse schemes have always been a key concern and matter of interest for the water professionals and researchers. In order to reduce the risk of potential failure of alternative water projects, it is of value to understand the context of each project. Unfortunately, the cases where public opposition in fact vetoed the water recycling schemes are not well documented. Thus, planners of new projects at other locations associated with the introduction of alternative water sources have not been able to learn from these experiences [7]. The current study attempts to evaluate the applicability of a SWOT analysis tool to identify the critical factors that are critical for the successful implementation of water reuse schemes. This paper only uses the available literature on existing successful and controversial water reuse projects for analysis.

2. Approach of study

The present study adopts a case study approach. Use of case studies as a research strategy, spans different disciplines including psychology, sociology, political science, history, anthropology and economics. It is a popular approach for studying issues concerning social and community based problems [8]. Case studies illustrate the general trends of the events leading to success or failure of a project. This study methodology incorporates single or multiple-case designs, where a multiple design must follow a replication rather than sampling logic. The generalization of results, from either single or multiple designs, is related to theory and not to populations [9]. Multiple cases strengthen the results by replicating the pattern-matching, thus increasing confidence in the robustness of the theory. The present study therefore adopts the multiple case study design method.

As the analysis tool, the use of SWOT analysis is made. SWOT represents Strengths, Weaknesses, Opportunities, and Threats. SWOT analysis is an important support tool for decision-making, and is commonly used as a means to systematically analyse an organization's internal and external environments. Every programme, project, development and management plan has its strengths and weaknesses, opportunities and threats. SWOT analysis identifies the organizational strengths (elements to leverage and build on) and weaknesses (areas to seek assistance and support) plus community opportunities (areas to leverage for program advantages) and threats (elements that could hinder the program). Hence, SWOT analysis can provide an insight to the ways and means of converting the threats into opportunities, and off-setting the weaknesses against the strengths. This analysis type of analysis can be undertaken for any idea, organization, person, product, programme or project [10]. The development of the technique is credited to Albert Humphrey from Stanford University, US [11]. SWOT analysis is often used in the preliminary stages of decision-making on one hand, and as a precursor to strategic management planning on the other [11].

When used appropriately, SWOT can provide a good basis for strategy formulation [12,13]. However, SWOT analysis does not provide an analytical means to determine the relative importance of the factors, or the ability to assess the appropriateness of decision alternatives based on these factors [14]. It however does articulate the factors in the analysis and allows analysts to categorize factors as being internal (Strengths, Weaknesses) or external (Opportunities, Threats) in relation to a given decision, and thus enables them to compare opportunities and threats with strengths and weaknesses [15].

3. Case study

The paper incorporates various water reuse schemes that are in operation in different parts of the world as its case studies. The information required for analysis was collected by reviewing the general project literature associated with the selected reuses schemes, the reports provided by the stakeholder organisations and relevant journal articles. Examples of unsuccessful water reuse schemes are found in many parts of the world. Our case studies however, are biased towards incorporating at least one example from Australia for both successful and unsuccessful reuse schemes.

3.1. Successful water reuse schemes

In the past 20 years, there have been significant developments in water reuse schemes all over the world and this has been attributed to the persisting and increasing water shortages as well as the development of new environmental policies and regulations. There are many water reuse schemes that have been successfully implemented. Monterey in California (US), Mexico City (Mexico), Dan Region (Israel), Virginia of Adelaide (Australia) are some of the examples where water reuse for agriculture has been successfully implemented [16]. St. Petersburg in Florida, Irvine Ranch and South Bay in California (US), Tokyo (Japan), Rouse Hill, Homebush Bay and Newington in Sydney, Mawson Lakes in Adelaide (Australia) are examples of successfully implemented projects for urban reuse [4,16]. Indirect potable reuse systems began more than 30 years ago in California in the US while the first potable direct reuse was introduced in Windhoek, Namibia in 1968 [2,17]. Indirect potable water reuse projects at Or-

ange county, Water Factory 21 in California, Fred Harvey Water Reclamation Facility located in El Paso, Texas, and the Upper Occoquan Sewerage Authority Water Recycling Project in North Virginia are some of the examples in US that have been implemented successfully [1,2]. NEWater in Singapore is another example of successful potable water reuse.Virginia, Adelaide in Australia and NEWater in Singapore have been chosen as case studies in this paper among the successful reuse schemes.

3.1.1. Virginia Adelaide, Virginia Pipeline Scheme (VPS), Australia

Virginia Pipeline Scheme (VPS) was commissioned in 1999 in Virginia, Adelaide was the first large-scale water recycling scheme in Australia that was used for irrigation purposes which uses treated wastewater from the Boliviar Waste Water Treatment Plant (WWTP) [18]. The region is known as South Australia's 'Veggie Bowl' because of its reputation of delivering high-quality horticultural products for local and interstate markets. VPS is a co-operative undertaking of the Virginia Irrigation Association — representing market gardeners and other irrigators; SA Water and Water Reticulation Systems Virginia — a private company.

In this region, as a result of over exploitation (extraction of about 18 giga litres (GL), where the sustainable limit is 8–10 GL) of the groundwater resources, which were formerly the main source of irrigation. Because this is beyond sustainable limits [4], the water levels in the aquifers declined and groundwater reservoirs reduced. The farmers essentially recognized the value and potential of this source of water that provided a secure supply irrigating their crop lands.

The increasing public sensitivity to environmental issues (which heralded the establishment of Environmental Protection Act (EPA) also created urgency to implement changes to Boliviar WWTP which would significantly reduce the nutrients discharged to the Gulf [19]. The government secured an AUD 10.8 million Federal government grant from the 'building better for our cities' program to support this scheme. Consequently, high quality treated Class A equivalent recycled water for irrigating agricultural crops without any restrictions was commenced by VPS [19]. This secondary effluent from the Boliviar WWTP then received further treatment by a Dissolved Air Flotation Filtration system which improves the water quality to less than 10 E. coli/100 ml (the Australian standard for irrigation for crops eaten raw) [20]. Good communications and effective partnerships between the key stakeholders were established through contractual agreements [21]. Communication strategies were carried out at different levels to train and educate the key stakeholders as well as provide adequate promotion. The social marketing of the scheme was also undertaken which includes endorsement of the scheme by the South Australia Department of Human Services and the EPA [18,21].

3.1.2. NEWater, Singapore

Singapore is a small island with few natural resources where half of the country's water supply is imported from Malaysia [22]. Ongoing negotiations between the two countries regarding the price of water is threatening Singapore's future water supply and is regarded as a very sensitive issue by both the government and the general public [4]. Hence, there was a significant need for local alternative sources of water to be identified based upon the recommendations from National Research Council USA. Project NEWater was commissioned on May, 2000 and in keeping with possible community resistance to consuming NEWater, only indirect reuse by mixing the recycled water with reservoir water was introduced [22]. At present recycled water constitutes 3% of potable water supply in Singapore it is expected that this will increase to 20% by 2015 [6].

Intensive education campaigns were undertaken to raise people's awareness of the quality of NEWater, by Singapore's Public Utilities Board (PUB). A documentary feature film with various media exposures, information briefings at community centres and schools, and a NEWater visitor centre [23]. There were initial reports of public hesitation to using the NEWater was established [24]. According to Seah [24], some people were ready to pay more for imported water rather drinking NEWater. An independent poll often cited by government is work undertaken by Forbes Research [23], which shows no agreement with these findings. The poll indicated an overwhelming level acceptance of NEWater by Singaporeans. Despite a few signs of public reservations in drinking recycled water, NEWater has been involved in the local water supply since 2003 [2].

3.2. Controversial water reuse schemes

Wastewater reuse incorporates the general public as the consumer hence it is often a sensitive issue. A number of water reuse projects have been observed to be unsuccessful because of lack of community confidence in the project. Some of the controversial water reuse schemes. include water reuse projects in Europe, Australia and the USA. Quakers Hill in Sydney, Maroochy, Toowoomba in Queensland (Australia) and San Diego, Tampa (US) [6,17]. There are many other issues that can be attributed to the failure of those projects. San Diego (US) and Toowoomba (Australia) have been considered for case studies in this paper as being controversial reuse schemes.

3.2.1. San Diego, US

For several years prior to 1990s, Southern California had benefited from the imported water from the Colodo

River Aqueduct which constituted approximately 90% of San Diego's supply [5]. The increasing demand and the decreasing supply from an imported source promoted the idea of introducing recycled water as a supplement to the city of San Diego's drinking water supply during the 1991–92 droughts [25].

A comprehensive research project was established in order to understand public willingness to use recycled water and to identify potential issues that needed to be addressed. The research included public opinion studies, group concerns and individual interviews with community leaders and policy makers. Various public outreach activities were undertaken including the distribution of brochures and related fact sheets, video presentations about the project, feature stories in newspapers and other media outlets, and a telephone enquiry line was also set up.

According to Katz and Tennyson [26], a telephone survey of more than 300 San Diego residents showed that a high number of respondents supported for the use of recycled water and repurified water for drinking, washing and cooking [2].

This proposed project was also submitted to the scrutiny of an Independent Advisory Panel and a citizens' review committee to gain more assurance for the general public [27]. Water officials at the San Diego County Water Authority (SDCWA) and the local water districts within the county, the academics, and private business experts all agreed that the reuse of water for drinking is safe, affordable and necessary. However, buttressing the notion to reject the proposal was the "yuck factor" associated with the recycled water and the concept of drinking such water might be a recipe for disease and a public health disaster. At the time of project's final approval, regardless of the strong support from a wide variety of community organisations, the project became entwined in political campaigns and become a political issue which eventually caused the whole project to be halted [20]. The campaigns claimed that the city intended to take wastewater from prosperous communities and distribute it as drinking water in less prosperous communities, and health dangers from the project were specifically highlighted. The State Department of Health Services consequently called a hearing associated with the impacts of the project. Most of the emotionally touched and worried residents turned up to the hearing after seeing advertised posters covered with the slogan "Toilet to Tap" [2]. In the end, the project was put on indefinite hold by the San Diego City Council [27].

3.2.2. Toowoomba (Australia)

The water situation in regional areas of Australia, such as Toowoomba, is critical. A policy result impact from the drought was the implementation of restrictions to water use. Toowoomba residents had been faced restrictions to water use since 2003. Level 1 restriction began in 2003, ultimately reaching level 5 restrictions in 2006, which continues until today [28].

With the aim of addressing the city's water challenges, at the beginning of July 2005, the 'Water Futures Initiative' (WFT) was announced by Toowoomba City Council. The construction of an advanced water treatment plant to provide potable quality recycled water for the town was one of the most prominent steps included as the part of the project [28]. As part of the proposal, Toowoomba City Council planned to undertake a three year community engagement program [29]. This was included in a policy document but there was little communication with the general public. 'Citizens against drinking sewage' CADS Toowoomba group was formed on the 21st of July 2005 and started a campaign of the public against the WFT which included providing detailed arguments against potable recycled water to the public. Six months later, on the 24th of February 2006, 10,000 people signed a CADS petition against the potable recycled water initiative [30]. Hence, CADS benefited from a 'First Mover Advantage' (refer Lieberman and Montgomery, 1988) as described by Hurlimann and Dolnicar [7].

The appeal was lodged on 30 June 2005 by the Toowoomba Council to the National Water Commission and this included funding towards the project that was already supported by all 9 Councillors (elected representatives at local government level), and by all local members of State and Commonwealth Parliaments [7]. Probably because of the increasing opposition of public towards the project, on the 24th of March 2006, Mr Malcolm Turnbull (Parliamentary Secretary to the Prime Minister) announced that a referendum would be held to see what the residents of Toowoomba thought with regards to the Water Futures Project [7]. The Federal Government had promised to contribute AUD 22.9 million towards the project but only if the public supported the project [31].

Toowoomba City Council was thus led into a situation where it had to condense a proposed three year community engagement program into a 2 and half month information campaign. By the time Council started informing the public, CADS had been communicating with Toowoomba residents for more than 6 months. Also, as opposed to CADS, Council were bound by Codes of Conduct, and thus had to ensure that campaign content was at all time 'above board' [7].

On the 29th of July 2006 the referendum was held in Toowoomba. The majority, 62% of residents, voted against the proposed recycled water scheme [32]. As a consequence the Water Futures Project was abandoned.

4. Analysis and discussion

This part of the paper incorporates the analysis and discussions on the selected successful reuse schemes as

well as the controversial reuse schemes. Based on the case studies, basic strengths of the successful water reuse schemes and the major weaknesses of the unsuccessful water reuse scheme have been analysed and discussed using SWOT analysis.

4.1. Successful water reuse schemes

4.1.1. Virginia Pipeline Scheme (VPS), Adelaide, Australia

4.1.1.1. Strengths and associated opportunities

According to Po et al. [2], developing a genuine partnership with the community such as to involve them in decision making process in order to build and maintain the trust among them is essential. VPS 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, which is one of the major supporters of the project.

The Virginia has a big market for its horticultural products and the irrigation is essential. The Virginia region accounts for approximately 35% of South Australia's horticultural production, which equates to about AUD 120 million or 68 million pounds [18]. The community had previously recognized the existing water scarcity problem, its consequences and the potential of the new alternative source of water to provide a secure supply for irrigating their crop lands. This realization by the target group is of value to the project. This realization by the growers, accompanied by the social, economic and the environmental drivers, led to the development of the VPS [33]. VPS produces class A water which is produced after a high level of treatment (i.e. full secondary plus tertiary filtration plus disinfection along with coagulation wherever necessary). According to Keremane and Mckay [21], this water is of better quality than many polluted river sources.

There exists an important role and well defined responsibility for each stakeholder, their enhanced participation, good communications and effectively designed partnerships between the key stakeholders through contractual agreements. Hartely [5] advocates that incorporating stakeholder priorities in water reuse programs is very important in successful implementations. Each group of stakeholders is performing their job with individual and organizational motivation. For example, VIA educates the growers in relation to water reuse. The irrigators were advised comprehensively about the benefits of the enhanced nutrient levels on soils and natural ground water by use of reclaimed water. This behaviour closely monitors the effects of the reclaimed water on the soils. Communication campaigns were carried out at different levels to train and educate the key stakeholders — industry, retailers, and the public. In addition, the wholesalers were kept informed about the developments in the scheme and reassured that product quality would not be compromised. Promoting communication and public dialog for providing them with the information about the benefits of the schemes has been considered as one of the important concerns by Hartley [5] and many other researchers. 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 consumer. The acceptance level of the products grown with reclaimed water was encouraging at all levels in the retail markets. The scheme is associated with many social, environmental and economical benefits. There has been new scope for development of export markets in the area. More job opportunities for the locals. The discharge of sewage effluent from the Bolivar wastewater treatment plant into the Gulf has been significantly reduced.

Thus, with sound policies, proper planning and management, sufficient financial commitments, and public awareness, support and participation, the VPS is operating successfully since it was commissioned and this has resulted in the economic, social, and environmental sustainability of the region (Table 1).

4.1.1.2. Weaknesses and associated threats

Currently, about 10 GL/annum of this reclaimed water is being used by horticulturalists, but the system can potentially deliver 23 GL/annum [4,33–35], hence, there is less demand than the production potential at present which many researchers [17,19,34] claim will be accommodated in future. Consumer acceptance of the use of reclaimed water in horticulture has been poorly studied in Australia. In a pilot survey of key Australian researchers, it was identified as the most important research priority (Dillon, 2000, 33]. Our study could not find specific study on costumer perceptions and attitudes regarding the VPS. According to Hamilton [34], many researchers claim that two key soil and water related constraints that need to be addressed when irrigating with reclaimed water are salinity and sodicity. Soil salinization is the most serious potential environmental hazard as a high sodium content in the irrigation water may reduce soil permeability and create an unsustainable environment for plant growth [34]. The growers still have some concerns about the impact of reclaimed water on the soil quality in the long run [21] (Table 1).

4.1.2. NEWater, Singapore

4.1.2.1. Strengths and associated opportunities

Singapore's future water supply was under threat and this has been regarded as a very sensitive issue by both the government and the people of Singapore. The realization that the need of secure and self sufficient water supply and belief in the government's ability to effectively address these issues are believed to be largely attributed

Table 1
SWOT analysis of Virginia Pipeline Scheme(VPS), Adelaide, Australia

SWOT analysis	VPS
S (Strength)	Public awareness of the water scarcity problem and potential of the new source. Adequate and effective communications Understandable explanation of the purification system and the water quality Effectively designed partnership among the stakeholders and their collective effort. Endorsement of the scheme by renowned organizations Advanced system of water purification Technically and socio-economically viable project Associated social, environmental and economic benefits
O (Opportunity)	Emphasis on alternative source of water. Build and maintain trust Easy social marketing of the benefits of the product. Development of belief and trust Motivation for enhanced participation of each group of Stakeholders Positive influence on people hence easy acceptance Strengthen the trust and enhance the confidence Ensure Fair and sound decision making Enhanced economy and environment
W (Weakness)	Less demand of the reclaimed water than the potential of the plant Lagging specific study on costumer perceptions and attitudes Soil salinization and sodicity is the probable impact of irrigation with reclaimed water
T (Threat)	Lagging end use options of reclaimed water Continuos monitoring of community attitudes is lag which may be dangerous in future In long run can have very bad effect on soil quality

to the success of the project. Community concerns and attitudes were given special considerations and appropriate planning was undertaken. Citing the fact that there have been no ill-health impacts to US citizens who consumed recycled water throughout the past 20 years. Better assurance of NEWater quality among the general public has been a strong strategy to ensure belief and trust among the general public. Po et al. [2] advocates that heightening people's awareness of water issues by providing information about successful reuse projects is very supportive that will help address the health risk concerns of the community. In a residential strategy survey conducted in different parts of Sydney, one third of the participants said that they would accept to use recycled water if they knew that other cities were safely using this water [36]. A major element of success of recycled water projects is community confidence that the treatment system is effective [37]. Advanced technology has been adopted for producing drinking quality recycled water. A comprehensive study concluded that the produced reclaimed water must meet both the US-EPA and WHO guidelines for drinking water that is purer than tap water [2,20]. Both the US-EPA and WHO guidelines for drinking water are very popular among the general public and they are very supportive of these guidelines.

This information was conveyed to the general public very effectively which was a major strength of the project. Intensive education campaigns with innovative approaches launched to raise people's awareness of NEWater can also be attributed to the success of the project. According to the Kyodo News International 2003, 1.5 million bottles of NEWater were distributed by the government for the general public to test and evaluate [2]. Top government officials and experts were photographed savouring the water. Singapore is a country where the government is strong and enjoys significant authority, which is also important when implementing recycle water use for drinking purpose [2,17]. Eventually the NEWater project has become a matter of pride for the people of Singapore (Table 2).

4.1.2.2. Weaknesses and associated threats

The pioneer in the field of research involving community attitudes towards the use of recycled water Bruvold [38,39] concluded that people are most opposed to using recycled water for "close-to-body" uses such as drinking and bathing. There were reports of public hesitation to using the NEWater [24]. According to Seah [24], some people were ready to pay more for imported water rather than having to drink NEWater (Table 2).

Table 2
SWOT analysis of NEWater, Singapore

SWOT analysis	NEWater
S (Strength)	Public awareness of the water scarcity problem and potential of the new source. Special considerations to community concerns and attitudes and the planning according to that. Declaration of the produced reclaimed water to meet both the US-EPA and WHO guidelines for drinking water. Innovative and extensive community information and education programs on time. Citing of another similar successful project in US. Technically and socio-economically viable project. Strong government with big authority
O (Opportunity)	Emphasis on alternative source of water. Build and maintain trust Development of belief, trust and confidence. Enhance the belief of the community and their participation. Build trust and confidence. Ensure Fair and sound decision making. Easy decision making and implementing.
W (Weakness)	Potable reuse. Some public show the squeamishness to drink this water
T (Threat)	Opposed to using recycled water for drinking purposes Possible impact on the one who supported the scheme.

4.2. Controversial water reuse schemes

4.2.1. San Diego, USA

4.2.1.1. Strengths and associated opportunities

In San Diego about 90% of water supply is from an imported source so that there is a significantneed to find a local alternative source. Water officials at the San Diego County Water Authority (SDCWA) and the local water districts within the county, the academics, and private business experts all agreed that the reuse of water for drinking is safe, affordable and necessary. The comprehensive research project was established in order to understand public willingness to use recycled water and to identify potential issues that needed to be addressed (Table 3).

4.2.1.2. Weakness and associated threats

The realization that water is being imported and there is a water supply problem in the city of San Diego seems to exist among the general public [5,37]. This lack of information is one of the major weaknesses of the project. There is a lack of providing adequate and understandable explanation of the purification system and the water quality to the general public. Extensive public education and outreach programs were launched but only after the project's conception hence planning was perceived to be done without public participation or knowledge creating an atmosphere of distrust. Po et al. [2] states that it is very important to involve the general public from the planning phase such as to maintain belief and trust. A lack of transparency at the earliest planning stages, and limited community outreach, characterizes the public consultation efforts at San Diego [17]. The pioneer in the field of this research Bruvold [38,39] concluded that people are most opposed to using recycled water for "close-to-body" uses such as drinking and bathing. Similar trend is observed in recent Australian studies [2,6,17,36]. Marks [17] advocates that non potable reuse is another feasible option to give a gradualist approach to the use of recycled water in general public. However, it was not fully developed or not established when potable reuse was being proposed in San Diego and neither was non potable reuse offered as an option in surveys of public opinion conducted at that location. Moreover, Okun [1] advocates where non potable reuse is feasible, that is a higher priority, as it carries the least public health risk and the greatest public acceptance.

Social marketing of the product which includes adequate promotion of the benefits of the project and adequate information about the source and quality of the product was lagging. The public campaign for the project did not adequately address public perception about the water quality and the source of water and lag of providing adequate and understandable explanation of the source of water, purification system and the water quality to the general public is perceived. There exists big communication gaps among the water reuse organisation and key stakeholders and also no adequate priority was given to each group of stakeholders. This gap is normally use

Table 3
SWOT analysis of San Diego, USA

SWOT analysis	San Diego
S (Strength)	Immense need of local source of water supply. The water professionals, academicians and researchers' support
O (Opportunity)	Good possibility of introducing recycled water as alternative source
W (Weakness)	Realization of need of secure and self sufficient water supply by the community was lagging Understandable explanation of the purification system and the water quality to the general public was lagging Public education and outreach programs start only after the project's conception but not from the beginning. The leadership of the project changed to San Diego's waste water department during the design phase. Big communication gaps exist between the water reuse organisation and key stakeholders. Inadequate social marketing of the product
T (Threat)	No emphasize on alternative water resources by the community Distrust the quality of water and concerns about health issues. Creation of Atmosphere of distrust. People perceived the change of goal of the project with the atmosphere of distrust. The communication gap is normally use by the opponents to built a wall. Less recognition from the public

by the opponents to built a wall. This leads to opposing campaigns which claimed that the city intended to take wastewater from affluent communities to distribute as drinking water to those less affluent, and specifically highlighted the health dangers from the project [20]. Health has been always a sensitive issue and a core concern of people in regards of using recycled water. The failure of reuse organizations to allay stakeholder doubts about possible health risks associated with water reuse is very detrimental to the failure of the project [40] (Table 3).

4.2.2. Toowoomba, Australia

4.2.2.1. Strengths and associated opportunities

Toowoomba residents have been faced with restrictions to water use since 2003. Level 1 restriction began in 2003, ultimately reaching level 5 restrictions in 2006, which continues till today [28]. Commission for funding towards the project was already supported by all 9 Councillors (elected representatives at local government level), and by all local members of State and Commonwealth Parliaments [7] (Table 4).

4.2.2.2. Weakness and associated threats

Toowoomba was the first and only project in Australia to use recycling water for drinking purposes. A community engagement program was agreed upon but not implemented in the initial planning phase. There exists a huge communication gap between the water reuse organization and the local stakeholders which was used by CADS by constructing a huge wall of information against the potable recycled water. Hence CADS was the benchmark of information to the general public with the first mover advantage. There was a lack of adequate and understandable explanation of the purification system and the water quality to the general public, probably the move towards that was too late and short. Also, the health related issues presented by CADS were not found well addressed and justified by the water reuse organizations. The concept of "toilet to tap" is emotionally charged as claimed by many researchers [39]. Similarly, the potential loss of fertility or other human functions that could result from the presence of an ever increasing number of designer pollutants and drugs in the water supply causes alarm [41]. Politics and vested interests are also the reasons behind the failure. Hurlimann and Dolnicar [7] summarize basically public opposition along with partly the politics, vested interests, timing and information manipulation as the reasons of failure of the project. Table 4 shows the details of associated threats.

5. Conclusions

From this study, the SWOT analysis can be successfully applied as a tool to identify the critical factors associated with the successful implementation of water reuse schemes. Best practice measures for the successful implementation of the water reuse schemes can be very diverse and vary from region to region. The feasibility of a water reuse schemes in social, economical and technical

Table 4
SWOT analysis of Toowoomba, Australia

SWOT analysis	Toowoomba
S (Strength)	Immense need of local source of water supply The water professionals, academicians and researchers' support
O (Opportunity)	Good possibility of introducing recycled water as alternative source
W (Weakness)	First project in Australia to use recycling water for drinking purpose Community engagement program was decided but not implemented from the initial phase. The move towards the public outreach was too late and short. Politics and vested interest have their own influence Lag of adequate and understandable explanation of the purification system and failure to allay the associated health risk with the scheme. A huge communication gap between the water reuse organization and the local stakeholders More emotional issues were highlighted by the opponents.
T (Threat)	People got the fear of being test sample. Creation of atmosphere of distrust. First mover advantage of "CADS" More focus on politics rather than the real problem. Distrust the quality of water and concerns about health issues. The communication gap is normally use by the opponents to built a wall. Emotional issues are always more adored by the general public

aspects plays an important role in deciding the project is viable or not. Consideration of community attitudes to the use of recycled water has been observed as one of the most critical components that drives the successful implementation of any recycled water project. Hence, the critical factors to be considered for successful implementation of the water reuse schemes revealed from this study are: (i) adequate social marketing and public outreach from the initial phase, (ii) political aspects are in favor of the project, (iii) strong financial means have been arranged by government and different stakeholders, (iv) the level of water stress and its realization by the general public, (v) public awareness of the potential of the reuse scheme and availability of other alternative water resources, (vi) the trust and belief of general public on the water reuse authorities, (vii) the variety of end users options available for recycled water to introduce a gradualist approach, and (viii) the advanced technology used thereby producing the water fit for purpose and the geographical properties of the catchment. Conclusively, integration of the diverse spectrum of issues, all of which are critical to the successful implementations of water recycling projects, but none of which can achieve progress alone.

Acknowledgements

This study was funded by UTS Challenge Grant.

References

[1] D.A. Okun, Water reuse introduces the need to integrate both water supply and wastewater management at local and regulatory levels, Wat. Sci. Technol., 46(6–7) (2002) 273–280.
[2] M. Po, J.D. Kaercher and B.E. Nancarrow, Literature review of factors influencing public perceptions of water reuse, CSIRO Land and Water, Perth, 2003, pp.1–39.
[3] A.N. Angelakis and L. Bontoux, Wastewater reclamation and reuse in European countries, Water Policy, 3 (2001) 47–59.
[4] J.C. Radcliffe, Water recycling in Australia, A review undertaken by the Australian Academy of Technological Sciences and Engineering, 2004.
[5] T.W. Hartley, Water Reuse: Understanding public perception and participation. Virginia, Water Environment Research Foundation, 2003.
[6] A. Hurlimann, Community attitudes to recycled water use — An urban Australian case study, part 2. Research Rep. No. 56, Cooperative Research Centre for Water Quality and Treatment. Salisbury, South Australia, 2008.
[7] A. Hurlimann and S. Dolnicar, When public opposition defeats alternative water projects — The case of Toowoomba Australia, Wat. Res., 44(1) (2010) 287–297.
[8] M.P. Johnson, Decision models for the location of community corrections centers, Environ. Planning B – Planning Design, 33(3) (2006) 393–412.
[9] R. Yin, Case Study Research — Design and Methods, 2nd ed., Beverly Hills, CA, Sage Publishing, 1994.
[10] G. Johnson, K. Scholes and R.W. Sexty, Exploring Strategic Management, Scarborough, Prentice-Hall, Ontario, 1989, p. 345.
[11] O. Arslan and I.D. Er, SWOT analysis for safer carriage of bulk liquid chemicals in tankers. J. Hazard. Mater., 154 (2008) 901–913.
[12] T. Hill and R. Westbrook, SWOT analysis: it's time for a product recall, Long Range Planning, 30 (1997) 46–52.
[13] I. Yüksel and M. Dagdeviren, Using the analytic network process (ANP) in a SWOT analysis — A case study for a textile firm. Info. Sci., 177 (2007) 3364–3382.

[14] M. Kajanus, J. Kangas and M. Kurttila, The use of value focused thinking and the A'WOT hybrid method in tourism management. Tourism Manage., 25 (2004) 499–506.
[15] R.K. Shrestha, J.R.R. Alavalapati and R.S. Kalmbacher, Exploring the potential for silvopasture adoption in South-Central Florida: an application of SWOT-AHP method, Agricult. Syst., 81 (2004) 185–199.
[16] J. Anderson, The environmental benefits of water recycling and reuse. Wat. Sci. Technol. – Wat. Supply, 3 (2003) 1–10.
[17] J.S. Marks, Taking the public seriously: the case of potable and non potable reuse, Desalination, 187 (2006) 137–147.
[18] B. Krackman, R. Martin and P. Sztajnbok, The Virginia pipeline: Australia's largest water recycling project. Wat. Sci. Technol., 43 (2001) 35–42.
[19] D. Stevens, J. Kelly, M. McLaughlin and M. Unkovich, Growing crops with reclaimed wastewater, CSIRO Publishing, Collingwood, Victoria, Australia, 2006, pp. 1–204.
[20] EPA, Guidelines for Water Reuse, U.S. Environmental Protection Agency, 2004.
[21] G.B. Keremane and J. McKay, Successful wastewater reuse scheme and sustainable development — a case study in Adelaide, Wat. Environ. J., 21 (2006) 83–91.
[22] H. Seah, J. Poon, G. Leslie and I.B. Law, Singapore's NEWater demonstration project, another milestone in indirect potable reuse. Water, J. Austral. Wat. Assoc., 30(4) (2003) 74–77.
[23] R. Collins, Hard sell for new water. Water Wastewater, 14(4) (2003) 39–40.
[24] C.N. Seah, Media blitz on the yuck factor. The star, http://www.singapore-window.org/sw02/020721st.htm, Accessed 02/04/2010.
[25] D'Angelo Report, See using reclaimed water to augment potable water resources. Public information outreach programs. Water Environment Federation and American Waterworks Association, 1998.
[26] S.M. Katz and P. Tennyson, Public education is the key to water repurification's success, A paper presented at Beneficial Reuse of Water and Biosolids, Malaga, Spain, April 6–9, 1997.
[27] J. Wegner-Gwidt, In: T. Asano, ed., Wastewater Reclamation and Reuse, CRC Press, 1998, pp. 1417–1462.
[28] Toowoomba City Council, Water restrictions, 2008, http://www.toowoomba.qld.gov.au/index.php?option¼com_content&task¼blogcategory&id¼286&Itemid¼447. Accessed 12/12/09.
[29] Toowoomba City Council. Water future of Toowoomba: taking control of Toowoomba's future, 2005, http://www.toowoombawater.com.au, Accessed 12/04/2009.
[30] M. Reynolds, Recycling receives a spray. The Australian, Adelaide. Finance, 28, 2006.
[31] D. Thorley, Toowoomba recycled water poll. Reform, 89 (2007) 49–51.
[32] Sydney Morning Herald, Toowoomba says no to recycled water, 2006, http://www.smh.com.au/news/national/toowoomba-says-no-to-recycled-ater/ 2006/07/29/1153816419568.html, Accessed 12/04 2009.
[33] J. Kelly, D.P. Stevens and T. White, Achievements of the Virginia pipeline scheme: horticultural production with reclaimed water. Proc. Water Recycling Australia: Second National Conference, Brisbane, 1–3 September 2003 (CD-ROM).
[34] A.J. Hamilton, A.-M. Boland, D. Stevens, J. Kelly, J. Radcliffe, A. Ziehrl, P. Dillon and B. Paulin, Position of the Australian horticultural industry with respect to the use of reclaimed water. Agricult. Wat. Manage., 71 (2005) 181–209.
[35] R. Thomas, In: D. Steven, Growing Crops with Reclaimed Wastewater, CSIRO Publishing, 2006, pp. 6–14.
[36] P.J. Dillon, Water reuse in Australia: current status, projections and research. In: P.J. Dillon, ed., Water Recycling Australia. CSIRO and AWA, Canberra, ACT, 2000, pp. 99–104.
[37] H.H. Ngo, H. Chuang, W.S. Guo, D.P. Ho, T.T.N Pham, A. Johnston, R. Lim and A. Listowski, Resident's strategy survey on a new end use of recycled water in Australia, Desal. Wat. Treat., 11 (2009) 93–97.
[38] K. Christen, Water Reuse: Getting Past the 'Yuck Factor'. Wat. Environ. Technol., 17(11) (2005) 11–15.
[39] W. Bruvold and P. Ward, Public attitudes toward uses of reclaimed wastewater. Wat. Sew. Works, 1970, pp. 120–122.
[40] W. Bruvold, Public Attitudes towards reuse of reclaimed water. University of California, California, USA, 1972.
[41] S.J. Khan and L.E. Gerrard, Stakeholder communications for successful water reuse operations, Desalination, 187 (2006) 191–202.
[42] A.I. Schaefer and S. Beder, Relevance of the precautionary principle in water recycling, Desalination, 187 (2006) 241–252.