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Measuring waste management performance using the 'Zero Waste Index': the case of Adelaide, Australia

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ABSTRACT

Adelaide is one of the high-consuming cities of the world that has developed and implemented a zero waste strategy to achieve optimum resource recovery from waste. Many similar cities are adopting a zero waste strategy with a key goal of 100% diversion rate of waste from landfill. This study argues that achieving a 100% diversion rate will be inadequate and does not reflect the core concept of the zero waste philosophy. In a previous study, the Zero Waste Index (ZWI) was presented as an alternative waste management performance assessment tool for zero waste management systems. The ZWI is a new indicator to measure and compare virgin material replacement by urban zero waste management systems. In addition, the ZWI quantifies energy, material and water conservation through recycling efforts rather than simply measuring waste diverted from landfills. In the current study, waste management performance in Adelaide during the years 2003–2010 is analysed using the proposed Zero Waste Index tool and thereby Adelaide's performance in waste management in 2015 and 2020 is predicted. The study indicates that waste composting is increasing significantly in Adelaide and by 2015 the amount of waste composted should be higher than that going to landfill. For this reason, the biological waste treatment infrastructure, particularly in waste composting facilities, should be stimulated in Adelaide. In addition, the study identifies that despite the zero waste strategy being in place, overall waste management performance in Adelaide may not reach the targeted zero waste goals, particularly in optimum resource recovery from waste. The projected results indicate that by 2020, if similar waste diversion rates continue, Adelaide should have reached a diversion rate of over 82% of municipal solid waste from landfill and the Zero Waste Index would then be 0.45 (around 45% material substitution from its current ZWI = 0.41 with a 72% diversion rate). The study also involved an online survey on the views of local waste experts in metropolitan Adelaide. By combining the waste performance and survey findings, the study identifies the most important priority areas for future waste management strategies in Adelaide.

1. Introduction

1.1. Background to the study

Currently, the world's cities generate about 1.3 billion tonnes of municipal solid waste (MSW) per year and the amount is expected to double by 2025 due to rapid urbanization, mass consumption and throw-away lifestyles (Gardner, 2012). Rapid urbanization, population growth, migration to urban areas, lack of sufficient funds and affordable services often force city authorities to offer unreliable and inefficient waste management services (Wilson et al., 2006). In many developing countries, city authorities often collect only 50–80% of waste and open dumping and landfills are frequently the only available disposal options (Medina and Dows, 2000). High consuming cities such as Adelaide are implementing different waste management strategies, in line with the concept of zero waste, to achieve the goal of 100% of waste diverted from landfill.

Zero waste management is a holistic waste management concept which recognises waste both as a resource and a symbol of the inefficiency of our modern society (Zaman and Lehmann, 2013). In traditional waste management systems, waste is considered an 'end-of-life' product, produced in the last phase of the product-consumption process. Zero waste challenges the traditional definition of waste by recognising that waste is a transformation of resources which happens in the intermediate phase of the resource consumption process. The resources that are transformed into waste as a result of our consumption activities

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should therefore be redirected into the production process through holistic zero waste management systems. Thus zero waste management is a combination of integrated design and waste management philosophies.

Within the zero waste philosophy, product design and waste management principles are considered simultaneously to eliminate potential threats to the environment caused by human consumption and unsustainable behaviour. Zero waste product design ensures that the discarded product is easily reused and/or repaired to extend the product's lifespan. A zero waste product is created by applying cradle-to-cradle design principles which eliminate waste from a product's life cycle. A zero waste product eliminates the 'waste phase' from the traditional product life cycle because after the end-of-life phase the zero waste product can either be reused, repaired or remanufactured to produce a secondary product. Zero waste management processes ensure that the discarded waste be recycled, recovered or easily nourished through natural processes, without polluting our natural environment. Hence the concept of zero waste safeguards the optimum utilization of natural resources with minimal environmental degradation.

Cities like Adelaide have been implementing different zero waste strategies and using the diversion rate as a key performance indicator to measure and quantify their progress. A recent study by Zaman and Lehmann (2013) opposed the commonly-held belief that zero end-disposal to landfill is the same thing as zero waste, and argued that this definition of 'diversion' does not place enough emphasis on how waste can be reused as a material resource (as opposed to being incinerated, for instance). Instead, the study took a broader look at urban resources, arguing that the city authority should target beyond the goal of zero landfill and aim for zero depletion of natural resources. The study also proposed a waste performance measurement tool called the Zero Waste Index (ZWI), which quantifies solid waste flows and measures the extent to which 'waste' materials may be reused as substitutes for virgin materials. In addition to the overall percentage of material recovery and substitution, the approach calculates other 'savings' made, including energy saved, greenhouse gases (GHG) avoided and water savings (regarding water usage within material supply chains). The ZWI provides details on sustainability outcomes such as resource, energy and water conserved through recycling efforts rather than simply measuring waste diverted from landfill. Hence the ZWI is significant for waste management authorities to understand and measure progress towards zero waste cities.

Since 2010, local government councils in the South Australian city of Adelaide have developed and implemented a zero waste strategy. The zero waste strategy in Adelaide prioritizes optimum recycling and zero landfill. Hence, the progress of waste management systems in Adelaide is measured by the waste diversion rate. This study aims to evaluate the usefulness of the ZWI as a waste management performance tool and to analyse municipal solid waste management performance in Adelaide by measuring resource, energy and water conservation from waste. In addition the study conducted an online survey of nineteen city councils in metropolitan Adelaide to identify potential priority areas in waste management strategies and possible future amendments. The study also aims to recommend potential future waste management strategies to help Adelaide's councils achieve the city's zero waste goals.

1.2. Previous related studies

A number of studies on solid waste management have been conducted by international organizations such as the World Bank (1998), Veolia International (2009), UN-HABITAT (2010), and scholarly researchers including Van de Klundert and Anschütz (2001), Wilson et al. (2001, 2006), Bovea and Powell (2006), Couth and Trois (2012). UN-Habitat's (2010) report on 'Solid Waste Management in the World's Cities' compared the integrated solid waste management and recycling systems of twenty cities around the world by considering their technological components, sustainability aspects and stakeholders' involvement. The study explored cities' different waste management systems, both formal and informal. The study's emphasis was on capacity building and technological advancement based on local conditions. The study concluded that there is no 'one size fits all' solution, therefore, by involving all stakeholders in designing, adopting and adapting waste management systems based on local conditions, an optimum solution to waste problems can be achieved.

The past decade has seen many researchers motivated to develop new approaches to waste management systems based on zero waste concepts. The major work in zero waste research has been done by Mason et al. (2003), Colon and Fawcett (2006), Braungart et al. (2007), Fujita and Hill (2007), Matete and Trois (2008), Kinuthia and Nidzam (2011), Phillips and Tudor (2011), Zaman and Lehmann (2011) and Curran and Williams (2012). This research has identified the most vital areas of zero waste studies as consumption of resources, individuals' consumption behaviour, and product design based on cradle-to-cradle principles (eco-effective product and system design), maximum waste diversion from landfill and optimum resource recovery.

Waste diversion rates (determined by calculating the amount of waste diverted from landfill) are one of the performance assessment indicators for waste management systems (Fehr and Santos, 2009; Yoshida et al., 2012). As a performance indicator, waste diversion has different socio-economic and environmental issues (Mazzanti et al., 2009) and has received criticism (Mueller, 2013) from researchers due to its limited forecasting capacity. In their study, Zaman and Lehmann (2013) proposed the 'Zero Waste Index' (ZWI) as an alternative performance assessment tool. The higher ZWI value represents higher substitution of virgin materials, energy and water saving i.e. higher achievement. The study compared the waste management performance of Adelaide, San Francisco and Stockholm based on the virgin material substitution factor, energy, GHG and water savings from their respective waste management systems. The study found that San Francisco's municipal solid waste management system has the highest virgin material substitution potentiality and that, in 2010, its Zero Waste Index was 0.51 with a 72% diversion rate followed by Adelaide (ZWI = 0.23) and Stockholm (ZWI = 0.17).

2. Methodology

This study is developed over two main sections. The first section reports Adelaide's waste management performance as measured by the Zero Waste Index tool. Waste management systems in Adelaide are analysed by material substitution, energy and water savings during 2003–2020. The second section reports the results of a survey on the views of waste experts in nineteen city councils in Adelaide. The survey was designed to get feedback from waste management experts in South Australia. Hence, the survey questionnaire was sent carefully to the participants who have different roles in waste management systems such as waste recycler, service provider, city council, local government, state government, NGOs working with waste management and so on. Finally, the priority areas in zero waste management systems are identified based on the performance assessment and survey data. The study concludes with some key issues as recommendations for achieving Adelaide's zero waste goals. The following sections briefly elaborate the performance assessment and survey methodology of the study.

2.1. Case study of municipal waste management in Adelaide

Adelaide is the fifth largest city in Australia with a total of 1,089,728 inhabitants living in 841.5 km^2 of urban area (UN-HABITAT, 2010). South Australia is often regarded as the driest state on the driest continent (Gargett and Marden, 1996). Adelaide is a high income and high consuming city; in 2010 the per capita GDP was US$41,300 (CIA, 2011). Almost 85% of South Australia's population live within the Adelaide metropolitan area. The Adelaide metropolitan area is managed by nineteen city councils. The remaining 15% of people live in rural and regional areas outside metropolitan Adelaide which are not covered by traditional waste management services provided by metropolitan waste authorities. Uncovered city councils outsource their management of waste collection to larger organisations, e.g. EastWaste collects for six local councils, one of which (Adelaide Hills) is outside the Adelaide metropolitan area.

2.1.1. Waste generation and composition

The composition of municipal solid waste varies widely, both within and between countries and during the different seasons of the year (UN-HABITAT, 2010). In the context of waste composition in Australia, information about the composition of municipal solid waste can be obtained from the Australian Waste Database (AWD) project. This database was jointly commissioned in 1993 by Australia's national scientific research body, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and the federal government's Department of Environment and Heritage to provide a monitoring mechanism for Commonwealth and State waste minimization policies and to address future waste management issues (Australian Waste Database, 2004). The AWD categorises organic, paper, glass, plastic, metal, hazardous and miscellaneous wastes as part of the composition of municipal solid waste. Despite the AWD's division of sources of waste into categories – including municipal, commercial and institutional, construction and demolition (C&D), hazardous and so on – the study found that an inconsistent waste composition is reported by considering C&D as a part of municipal solid waste in Adelaide. This inconsistency was also reported in the UN-HABITAT (2010) waste study.

The average composition of MSW in Adelaide is organic (26%), paper (7%), plastic (5%), glass (5%), metals (5%) and others (52%, mostly C&D). A total 742,807 tonnes of municipal solid waste (a significant amount of which is C&D waste) was generated in 2009 and the average person generated around 681 kg of MSW. South Australia possesses the highest waste recycling and resource recovery records in Australia. Waste recycling and composting are the main waste management techniques in Adelaide. In 2009, around 54% of all MSW was diverted from landfill. Landfill is still the main waste municipal method and accounts for 46% of municipal waste disposal (UN-HABITAT, 2010).

2.1.2. Waste collection and recycling

Adelaide's local councils provide waste bins (general waste and recycling) to residents. Waste bins are emptied by waste collection vehicles and the contents taken to a transfer station. There are fourteen medium to large scale transfer stations operating in the Adelaide metropolitan area (SA, 1999). After sorting and processing in the transfer station, waste is sent to landfill. South Australia has a long and successful history of implementing Container Deposit Legislation (CDL), which began in 1977. CDL captures a broad range of beverage containers up to 3 L that contribute to the litter stream, such as drink containers (flavoured milks, juice, water, soft drinks, beverage bottles and so on.) and excludes plain milk and wine in glass containers. A total 124 approved collection depots are operated state-wide, 40 in the Adelaide metropolitan region and 84 in regional South Australia, for the return of packaging containers. A 10 cent refund is paid for every container, which is why informal waste recyclers are playing an important role in recycling bottles and plastic containers from roadsides and public parks' waste bins. There is no specific law whether informal waste picking in South Australia is legal or prohibited, rather, informal waste picking has been treated as a source of secondary income and is favourable to the CDL programme. Fig. 1 shows an example of such informal waste recycling in Adelaide.

In spite of the availability of formal waste collection services in Adelaide, it is interesting and significant that these coexist with informal waste collectors who collect containers to get the refund for extra income. The rise of such informal collection within formal waste management systems suggests the efficacy of positive financial incentives. Informal recyclers are mainly recycling from the roadsides and public bins. Even though this collection is informal and voluntary, the system is integrated with the formal waste management systems because informal waste collectors return containers to collect the refund from a formal waste recycling depot.

2.1.3. Waste treatment and disposal

According to state legislation, city councils are obligated to empty general waste bins weekly and recycling waste bins fortnightly. Fig. 2 shows a schematic flow diagram of municipal solid waste management in Adelaide. The collected recyclable materials are transferred to recycling industries in Australia and abroad. Only glass, concrete, bricks, soil and rubble, asphalt, timber, food and garden organics are reprocessed in South Australia. Other recovered materials such as paper, plastics, steel, non-ferrous metals, textiles and rubber, are largely reprocessed interstate or overseas (Zero Waste SA, 2007).

The local City Corporation provides waste services to citizens and collects waste from households via kerbside waste collection systems. Informal waste recyclers recycle bottles and cans from public waste bins in parks, precincts and roadside areas due to refund systems. All recyclables (bottles, plastics, metals, glass and so on) are sent to recycling industries for remanufacturing new products. Household waste is collected and sent to transfer stations for recovery processing. The local recycling industries have been promoted by the state's zero waste strategies and hence, a significant amount – around two million tonnes (82%) – of waste is treated locally in South Australia, 5% (123,250 tonnes) is treated

Fig. 1. Informal waste recycling in Adelaide, Australia.

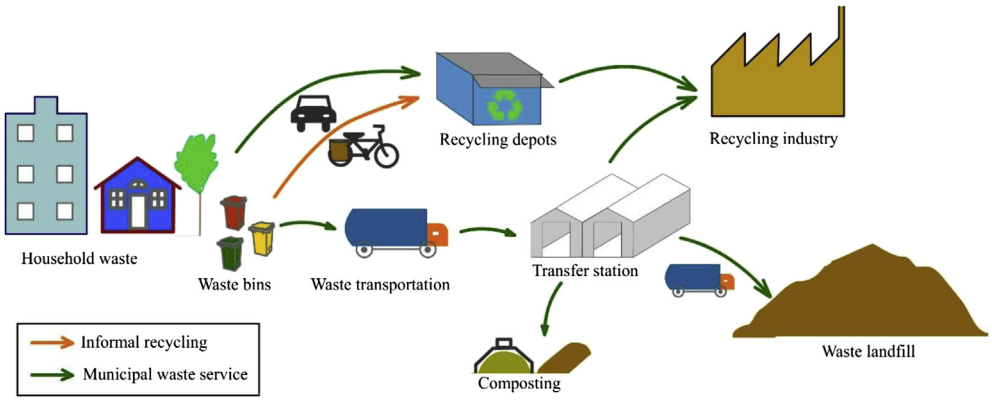

Fig. 2. Schematic flow diagram of municipal solid waste management in Adelaide.

interstate, while 13% (325,177 tonnes) is shipped overseas (ZWSA, 2011a).

Ten out of nineteen city councils in the Adelaide metropolitan area offer some form of garden waste collection system. Around 35% (157,000) of all households in metropolitan Adelaide have a garden waste collection service (EPA-SA, n.d.). Most of the transfer stations in South Australia accept almost all types of waste including hazardous; however, only electronic waste can be deposited for free. Organic waste drop-off fees range from AUD8 to AUD150 depending on the volume of waste and the transfer station. Hazardous waste is accepted by selected recycling depots and costs between AUD80 and AUD330 for asbestos and wet paint (IWS, 2013; NAWMA, 2013). After resource recovery, the residual wastes are sent to landfill sites. There are nine landfill sites currently operating in the metropolitan area (EPA and LGA, 2003). The total capacity of these sites is around 43 million tonnes of putrescible waste disposal and their anticipated lifespan is until 2030 (DEWHA, 2009). The South Australian waste levy has increased from AUD21 per tonne in 2007 to AUD42/tonne in 2010 for the metropolitan area and AUD21/tonne for the non-metropolitan area. A further increase in 2012 was proposed to raise the levy to at least AUD50/tonne to meet the target of a 35% reduction of waste to landfill by 2020 (ZWSA, 2013a).

2.1.4. Regulatory policies and strategies

The Container Deposit Legislation (CDL) has had – and continues to have – significant influence on waste management systems in South Australia. Adelaide has a higher percentage of waste recycling compared to the other capital cities in Australia due to the adoption of CDL in 1977. The Zero Waste SA Act (2004) was another of South Australia's more significant waste management initiatives because it formed the organization Zero Waste SA to promote zero waste activities throughout the state. Zero Waste SA has been working on many different aspects of waste such as promoting public awareness and knowledge of waste, waste avoidance, recycling, sustainable waste management and diversion of waste from landfill. The key events and regulations that relate to Adelaide's municipal waste management are presented in Table 1.

2.1.5. Waste management development drivers

Environmental awareness and climate change are the global drivers of waste management development (UN-HABITAT, 2010). The CDL is one of the main drivers of package and bottle recycling in Adelaide. Raising the refund for recycling packaging from 5 to 10 cents encouraged people to sort and recycle them rather than send it to landfill. Zero Waste SA (ZWSA) is the key government body driving waste reduction, recycling and reuse practices in Adelaide. The South Australian Government's commitment to the zero waste goal is not limited to the establishment of ZWSA, as it also supports the organization with strong financial inducements. 50 cents out of every dollar comes from public taxes and government funds are made available to Zero Waste SA for initiatives which divert waste from landfill (UN-HABITAT, 2010). Hence, economic incentives are

Table 1
Key milestones in Adelaide's municipal waste management systems.

Year	Milestones in MSW	Goal and focus	References
1977	Container Deposit Legislation	An important law for recycling of packaging waste	EPA-SA, 2012
1993	Environment Protection Act	Under the national environmental protection act, environmental pollution, emissions from waste, waste depot levy are regulated	Govt.-SA, 2013
1993	Waste Minimization Policies	A mechanism to monitor Commonwealth and State waste minimization policies and address future waste management	Australian Waste Database, 2004
1994	Environment Protection (Fees and Levy) Regulations	Landfill fees and waste levy are regulated	Govt.-SA, 2013
2008	10c Refund system	Deposit on beverage containers increased to 10 cents	EPA-SA 2012 http://www.epa.sa.gov.au/environmental_info/waste/container_deposit_legislation
2004	Zero Waste SA Act	Establishment of Zero Waste SA organization	ZWSA, 2011b
2009	Plastic Bag Ban	Single-use shopping bags banned in South Australia	EPA-SA, 2012
2011	Zero Waste Strategy 2011–2015	35% reduction of waste to landfill by 2020, to beachieved by reaching a milestone of 25% reduction by 2014 and achieving a diversion rate of 70% by 2015	ZWSA, 2011a
2012	Product Stewardship Regulation	Manufacturing activity related to products or waste including reuse, recycling, recovery and disposal during supply and use phase	EPA-SA, 2012

Table 2
Substitution values of the resource from waste management systems for the Zero Waste Index.

Waste management systems	Waste category	Virgin material substitution efficiency (tonnes)	Energy substitution efficiency (GJLHV/tonne)	GHG emissions reduction (CO_2e/tonne)	Water saving (kL/tonne)
Recycling	Paper	0.84–1.00	6.33–10.76	0.60–3.20	2.91
	Glass	0.90–1.00	6.07–6.85	0.18–0.62	2.30
	Metal	0.79–0.96	36.09–191.42	1.40–17.8	5.97–181.77
	Plastic	0.90–0.97	38.81–64.08	0.95–1.88	−11.37
	Mixed	0.25–0.45	5.00–15.0	1.15	2.0–10
Composting	Organic	0.60–0.65	0.18–0.47	0.25–0.75	0.44
Landfill	Mixed MW[a]	0.00	0.00–0.84[b]	(−)0.42–1.2	0.00

A positive value represents the savings and a negative value represents the demand or depletion.
[a] Average composition of municipal waste.
[b] Energy from landfill facility.

also a significant driver of development in Adelaide's waste management.

Community engagement, particularly in food waste recycling, is one of the major drivers in waste management systems in Adelaide. Local government (city councils) has been promoting organic waste recycling by providing separate bins for food waste collection to households. Different non-profit organizations have been working in Adelaide to promote food donation from processing industries, groceries and restaurants to feed homeless people. Regulations promote greater recycling and restrict certain waste types going to landfill. The provision of second-hand shops and online-based swap options are also increasing to promote reuse and reselling of the used products and avoid the creation of unexpected waste.

2.1.5.1. Using the Zero Waste Index to analyse waste management performance in Adelaide. The ZWI measures the opportunities and materials substituted by waste management systems in both environmental (resource) and economic terms. At present, the 'waste diversion rate' is used by cities to identify their achievements in waste management. However, the diversion rate does not capture the real potential for virgin material replacement efficiency by the waste management system which is very important for the conservation of global natural resources. The ZWI is a new indicator to measure and compare the rate of virgin material replacement by urban zero waste management systems. Use of the ZWI will enable the correct valuation of potential virgin material offset and avoidable depletion of natural resources. For simplification, the model has six broad categories of waste – organic, plastic, paper, metal, glass and mixed municipal solid – and has considered the available waste treatment technologies used in Adelaide (composting, recycling and landfill). The mathematical formula of the ZWI is calculated as in equation (i):

$$\text{Zero Waste Index(ZWI)} = \frac{\sum \text{potential amount of waste managed*substitution factor for the system}}{\text{Total amount of waste generated and managed}}$$

$$\text{ZWI} = \frac{\sum_{i=1}^{n} (\text{WMSij*SFij})}{\sum_{1}^{n} \text{GWS}} \quad \text{(i)}$$

where,

WMSij = amount of waste streams i (i = organic, plastic, paper, metal etc.) managed by different systems j (j = composted, recycled, incinerated, etc.)

SFij = Substitution factor for different waste streams (i = organic, paper, plastic, etc.) for different management systems (j = compost, recycle, incinerated, etc.) based on their virgin material replacement efficiency

GWS = Total amount of waste generated (i = 1 to n, all waste streams)

The substitution value is based on waste categories and waste management systems and is listed in Table 2. The table is adapted from different life cycle studies and databases, including: Morris (1996), Grant et al. (2001), Grant and James (2005), US-EPA (2006), Van Berlo (2007), DTU Environment (2008), DECCW (2010), Metro Vancouver (2010), UN-HABITAT (2010), CEF (2011), CIA (2011), Massarutto et al. (2011), Zaman (2010), Zaman and Lehmann (2011), Larsen et al. (2012).

The equation used substitution values of resources from waste based on the resource recovery efficiency for different waste streams. A total of six broad municipal solid waste categories were considered in the Zero Waste Index. The substitution value refers to the virgin resource substitution rate, i.e. the efficiency of virgin materials' recovery from waste streams such as paper, plastic, metals and so on. Based on the technological advancement with regards to the resource recovery efficiency and waste types, the resource recovery rate can range from low to very high. Table 2 shows the substitution of virgin materials from paper, glass, metal, plastic, organic and mixed waste streams. Due to the virgin materials substitution, potential energy, GHG emission and water savings are also counted in the Zero Waste Index. Hence, the Zero Waste Index not only counts the amount of virgin materials substituted from waste but also measures the potential savings of energy use, GHG reduction and water due to avoided virgin material extraction for production processes.

2.2. Inventory survey on waste management strategies

The main purposes of the survey are to understand firstly, the motivation for zero waste activities in metropolitan Adelaide among waste management organizations such as local and state government (city councils, regulatory bodies), waste business organizations (service businesses, recycling industries, etc.)and non-government organizations. Secondly, to determine future waste

management priorities based on the survey (and performance assessment results). The questionnaires were sent to local waste authorities and management organizations including city councils, state authorities, local business organizations, service providers, non-government organizations and so on. The survey population was limited to waste management organizations and experts involved in waste management in the Adelaide area and thus the study did not consider individuals or households.

The zero waste inventory survey is based on the following broader waste management issues:

- awareness and education
- waste avoidance and reduction
- waste recycling and treatment
- waste disposal
- regulatory policy
- zero waste management
- emerging priority areas in zero waste

A semi-structured questionnaire was prepared using multiple choice answers for participants to agree or disagree on particular questions. A number of questions were structured based on ranking systems from 'least important' to 'most important'. Based on the participants' rating and frequency of 'agree' or 'disagree' responses, the most important priority areas for zero waste strategies have been identified and are presented in the results section.

3. Results and discussion

3.1. Waste management performances in Adelaide

3.1.1. Waste diversion from landfill in Adelaide

Despite a successful start at the beginning of implementation, South Australia's first five-year zero waste strategy (2011–2015) has been experiencing the consequences of the global economic downturn. There has been a significant government investment of about AUD4.5 million for waste infrastructure, which boosted an additional AUD10 million in industrial ventures and stimulated an increase in tonnes of material diverted from landfill and, in some cases, resulted in additional employment in South Australia (ZWSA, 2013b). The core zero waste goals are a 35% reduction (with a milestone of 25% by 2014) in landfill disposal from the 2002–2003 level by 2020, and a 5% reduction in per capita waste generation by 2015. The waste strategy has two milestones for municipal solid waste diversion: a 60% reduction by 2012 and a 70% reduction by 2015 (ZWSA, 2011a). In addition, for C&D waste, targets for diversion from landfill were set to 85% by 2012 and 90% by 2015.

Using time series waste generation and management data and by considering the projected targets in the waste strategy, waste data for the years 2015 and 2020 were projected, adapted and are presented in Table 3. The following four assumptions have been made to project waste generation and management in the Adelaide metropolitan area:

- the waste generation rate increased 42% in 2010 compared to the previous year because municipal waste streams include C&D waste and a massive infrastructure development project has started in Adelaide, hence the overall generation of waste has increased significantly;
- the waste generation rate is assumed to have increased by 25% (the same as in the past 5 years) during 2015 and 2020;
- waste composting is assumed to have increased 12% (the same as in the past 5 years) during 2015 and 2020;
- waste sent to landfill is assumed to be meeting the targeted 35% reduction in landfill disposal from the 2002-03 level by achieving the 2020 milestone of 25% by 2014 as per Zero Waste SA's strategy.

Despite a municipal solid waste diversion target of 60% by 2012 and 70% by 2015, the study indicates that the projected diversion rate would increase to over 78% by 2015 and over 85% by 2020 if the waste disposal to landfill rate can be reduced to the targeted rate. The reason for these higher levels of waste diversion rate is due to C&D waste also being included in the municipal waste data. If a significant amount of C&D is recycled and diverted and recorded as a fraction of municipal solid waste this is a misleading figure for municipal waste diversion from landfill. If C&D waste is not considered in MSW then the waste diversion rate would be lower than the projected diversion rate. This is due to limitations in the data on standalone municipal solid waste fractions in waste reporting in South Australia.

3.1.2. Zero Waste Indexes for the years 2003–2020 in Adelaide

The Zero Waste Indexes in metropolitan Adelaide have been calculated based on Equation (i) (above). Based on the substitution value (in Table 2) of resources from waste in different waste

Table 3
Municipal waste generation and management in Adelaide.

Indicators	Year								
	Past years							Projected years	
	2003	2005	2006	2007	2008	2009	2010	2015	2020
Population (thousand)	1534	1550	1584	1602	1622	1644	1657	1770	1856
Waste generated tonnes (thousand)	3320	3554	3578	3741	3624	3795	5394	5108	6694
Per capita waste generated kg/cap	2164	2293	2258	2334	2233	2308	3294[a]	2885[b]	3606[b]
Waste composted tonnes (thousand)	246.8	565.9	571.7	528.9	504.9	635.8	954.4	1068[c]	1196[c]
Waste recycled tonnes (thousand)	1795	1830	1862	2082	2047	2124	3356	2937	4507
Waste diverted tonnes (thousand)	2042	2396	2434	2611	2552	2760	4310	4005	5703
Waste landfilled tonnes (thousand)	1278	1158	1144	1130	1072	1035	1084	1103[d]	991.4[d]
Per capita landfill (kg/person)	830	750	720	710	660	630	650	623	534
Waste diversion rate in %	61.5%	67.4%	68.0%	69.8%	70.4%	72.7%	79.9%	78.5%	85.2%
Per capita diversion rate (kg/person)	1330	1550	1540	1630	1570	1680	2600	2262	3072

[a] Waste generation rate has increased 42% in 2010 compared to the previous year because municipal waste streams include C&D waste and a massive infrastructure development project has started in Adelaide, hence the overall generation has increased significantly.
[b] Waste generation rate is assumed to increase 25% during 2015 and 2020.
[c] Waste composting is assumed to increased 12% during 2015 and 2020.
[d] Waste to landfill is assumed to be meeting the targeted 35% reduction in landfill disposal from the 2002-03 level by achieving the 2020 milestone of 25% by 2014 as per Zero Waste SA's strategy.

Table 4
Time series Zero Waste Indexes in waste management systems in Adelaide.

Indicators		Years								
		Past years							Projected years	
		2003	2005	2006	2007	2008	2009	2010	2015	2020
Recycling	Paper	136	175.6	175.2	215.7	204.1	222.3	211.3	255	308
	Glass	45.6	50	50.1	53.2	61.6	57	58	67	78
	Metal	296.2	319.7	369.0	411.6	311.7	375.8	441.5	609	840
	Plastic	8.6	15.9	16.9	15.3	13.8	20.5	23.7	35	52
	Mixed	1308.8	1268.9	1251.1	1386.3	1455.9	1448.6	2621.1	1971	3228.6
Compost	Organic	246.8	565.9	571.7	528.9	504.9	635.8	954.4	1068	1196
Landfill	Mixed	1278	1158	1144	1130	1072	1035	1084	1103	991.4
Total waste managed		3320	3554	3578	3741	3624	3795	5394	5108	6694
Waste generated (kg/cap)		2164	2293	2258	2334	2233	2308	3294	2885	3606
Zero Waste Index		0.32	0.37	0.38	0.39	0.37	0.41	0.40	0.44	0.45

management systems, Table 4 shows the potential amount of virgin resources recovered in metropolitan Adelaide during 2003–2010 and in the projected years of 2015 and 2020. The average substitution value from Table 2 has been used to calculate the Zero Waste Indexes. The projected data shows that the average person in Adelaide would generate 5,108 kg/year of waste in 2015 and 6,694 kg/year in 2020 despite the state's waste reduction strategy. Given that the consumption of resources increased during 2003–2010, it is reasonable to assume that there would be similar trends of an increasing consumption rate in Adelaide.

From these figures, the study identified that the waste reduction strategy and targets will not be achieved in Adelaide and the generation rate will continue to rise. Fig. 3 shows the projected amount of municipal waste managed in Adelaide by composting, recycling and landfill. From Fig. 3 the study identified that the amount of waste managed by composting would be higher than the amount of waste sent to landfill after 2015. There is a sharp increase in the waste recycling curve due to higher C&D waste composition and recycling rates in Adelaide.

The potential amount of materials recovered in waste management systems in Adelaide are presented in Table 5. The amount of virgin materials of paper, plastic, metals, glass, composted and mixed products substituted would reduce the demand for resources during the extraction phase of product manufacture. The study also calculated potential energy, GHG emissions and water savings due to the substitution of recovered resources for virgin materials extracted for production processes.

The resources recovered from waste are increasing in Adelaide over time. Fig. 4 shows the potential virgin material substitution in paper, plastic, glass, metal, compost and mixed materials during 2003–2020. As Adelaide's municipal solid waste's mixed waste category consists of C&D waste, resource recovery from mixed waste has the highest recovery rate in the diagram. Compost products such as mulch and organic fertiliser from composting have also been rapidly growing in Adelaide. There is a sharp rise in metal collection after 2009 because of the 10 cent refund system. Resource recovery from paper has increased since 2010 and will continue to increase until 2020. For glass and plastic, the recovery rates are similar and steady.

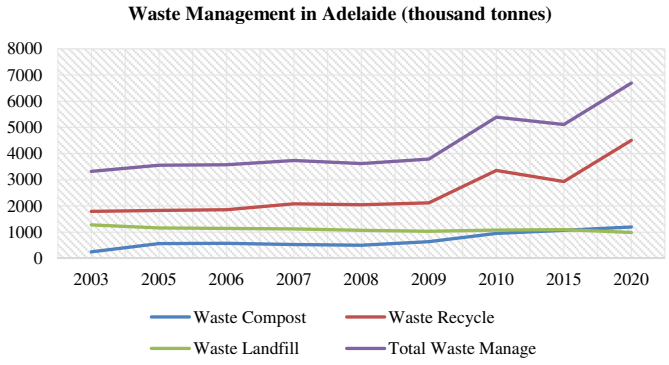

Fig. 3. Municipal waste management in Adelaide during 2003–2020.

3.2. Survey on municipal solid waste management in Adelaide

3.2.1. Participants' backgrounds

Around fifty waste experts from metropolitan Adelaide were invited to participate in the online survey which was open from August 2012 to October 2012. 24 waste experts ($n = 24$) from nineteen city councils and local government authorities responded to this questionnaire survey. The response rate was 48%. 71% of respondents were male and 29% female. 13% of respondents were aged 18–35 years old, 79% were aged 35 to 65 and 8% were over 65.

3.2.1.1. Participants' affiliations. A variety of waste professionals from different sectors participated and provided feedback through the questionnaire. Participants were affiliated with organisations including local government, state government organisations, environmental organisations, non-government organisations, community organizations, waste service providers and so on. The response rate is seen to vary in different sectors. Response rate depends on the number of participants invited for the survey and the willingness of the invited individuals to participate in the questionnaire survey. Fig. 5 illustrates that almost half of the participants (47%), were from local government, i.e. city corporations. Around 20% were from central governments, mainly from regulatory bodies and organizations like the environmental protection agency. Business, environmental organisations and service providers each accounted for 7% of participants' affiliations. The rest of the groups represented all contributed the same number of participants (3%).

3.2.1.2. Participants' level of environmental concern. The survey also asked questions to analyse the participants' level of environmental concern, about global sustainability, climate change and waste problems. As shown in Fig. 6, almost every participant was concerned about environmental problems. Only one expert appeared to be not at all concerned about global sustainability and climate change. Thus, the survey was responded by people who have a considerable interest in environmental issues.

3.2.2. Survey responses to Zero Waste management in Adelaide

3.2.2.1. Awareness and waste avoidance. Raising awareness and increasing education could potentially improve waste management

Table 5
Material substitution from municipal solid waste in Adelaide (thousand tonnes).

Indicators	Years								
	Past years							Projected years	
	2003	2005	2006	2007	2008	2009	2010	2015	2020
Substitution from paper	125	161	161	198	187	204	194	234	283
Substitution from glass	43	47	47	51	58	54	55	63	74
Substitution from metal	260	280	324	361	273	330	388	535	739
Substitution from plastic	8	15	16	15	13	19	22	33	49
Substitution from mixed	458	444	437	485	509	506	917	690	1130
Substitution from compost	155	356	359	332	318	400	601	672	753
Total material substituted	1049	1303	1344	1442	1358	1513	2177	2227	3028
Material substitute (kg/cap)	684	841	848	900	836	920	1314	1257	1631
Energy substitute (GJ/cap)	23.5	25.1	27.7	30.5	23.9	28.3	34.2	40.7	54.5
GHG emissions saving (kg/cap)	2200	1799	2030	2308	1805	2160	2793	3329	4638
Water savings (kL/cap)	18	19	21	23	18	21	26	31	41

systems. Unfortunately, it is difficult to transform education and knowledge into everyday practices. The survey asked waste experts whether they agreed or disagreed that: lack of awareness and proper knowledge on waste are mainly responsible for waste problems; awareness and knowledge promotes behaviour change; and whether community engagement fosters awareness and knowledge sharing. Fig. 7 shows the frequency of respondents' agreement or disagreement with the statements. Almost every expert agreed that lack of awareness and proper knowledge on waste creates waste problems and that community engagement and awareness programmes foster better waste management. A majority strongly agreed that awareness and knowledge encourages individuals to change their behaviour.

Waste avoidance is at the top of the waste management hierarchy. However, in many cases, a low priority has been given to waste avoidance when developing waste strategies. Strategic waste avoidance policy requires a multidisciplinary approach and a multi-stakeholder commitment. From the individual level to the local government and production industry level, avoidance techniques should be adapted and integrated. Experts were asked whether or not people's current busy lifestyles and individual willingness to implement avoidance practices play a significant role in overall waste avoidance. They were also asked to what extent they agree or

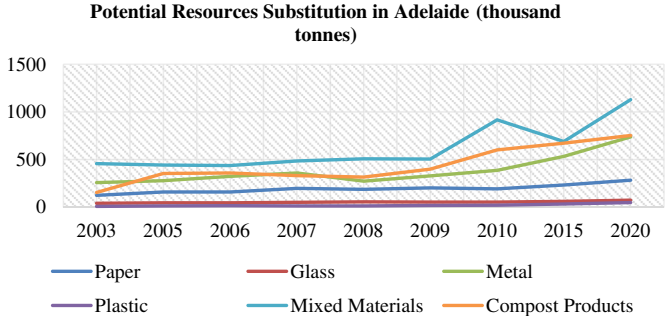

Fig. 4. Potential per capita substitution of resources from waste in Adelaide.

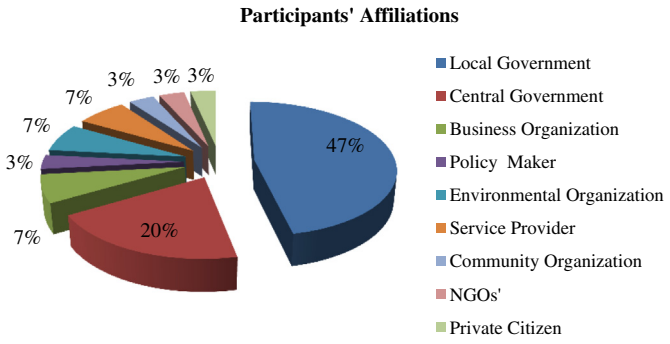

Fig. 5. Participants' affiliation.

disagree on the implementation of cradle-to-cradle design and local government production policy to enhance cradle-to-cradle design. Fig. 8 shows the frequency of their agree/disagree responses to waste avoidance statements.

Around half of the experts disagreed that a busy lifestyle is a barrier to waste avoidance and that local government should be involved in cradle-to-cradle production policy. There is no indication from the survey findings whether this is a role for state government or if it should take such cradle-to-cradle initiatives. But a few experts agreed that local government should take cradle-to-cradle initiatives. Individual willingness and cradle-to-cradle design are considered key waste avoidance methods by the experts surveyed.

3.2.2.2. Waste collection. Kerbside collection and transportation of waste is a significant economic cost for waste management authorities. Effective collection and recovery depends on collection systems, infrastructures and the economic benefits of the collection systems. The participants were asked whether recently introduced kerbside waste collection systems are an effective system in Adelaide. Community recycling systems and separate waste bins for various waste streams are very effective in many countries such as Sweden, which also imposes higher waste collections fees. Fig. 9 shows that majority of experts agreed that kerbside waste collections and community waste recycling places are desirable. Mixed feedback was received in relation to separate bin systems. The reasons for this may vary, as with the other waste infrastructure such as transfer stations or recycling facilities. A majority of the experts disagreed with higher collection fees.

3.2.2.3. Waste recycling. The recycling rate indicates the performance of waste management systems in a city. Adelaide has been

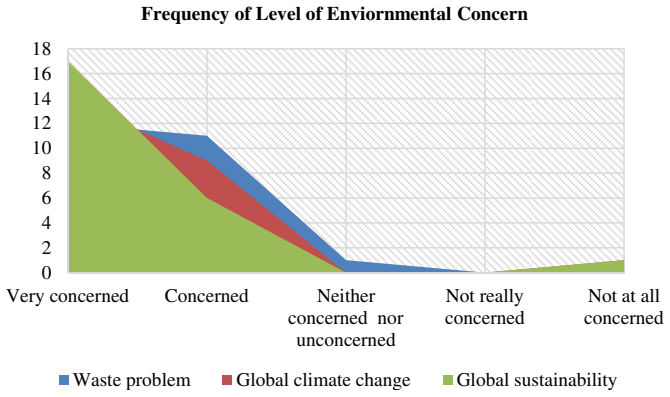

Fig. 6. Participants' level of environmental concern.

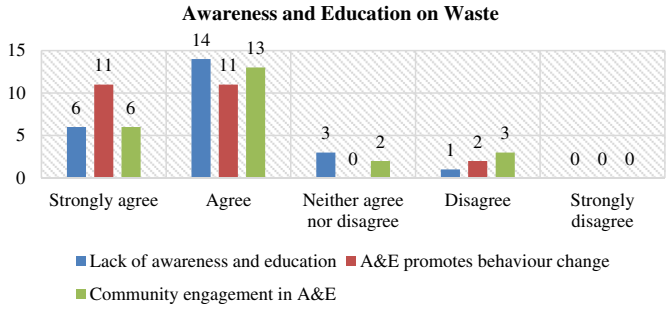

Fig. 7. Frequency of experts' agreement or disagreement that awareness and knowledge of waste matters.

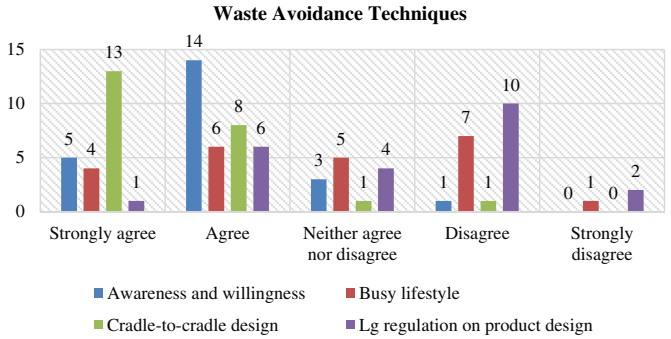

Fig. 8. Frequency of respondents' agreement and disagreement on waste avoidance statements.

successfully implementing CDL policy for more than three decades. The waste experts in Adelaide were asked to respond to several questions on waste recycling with 'yes', 'no' or 'unsure'. 22 out of 24 experts said that waste diversion is a good waste indicator. Mixed feedback was received on whether a 100% diversion or recycling rate is achievable. The majority of the participants agreed that CDL refund systems promote recycling in Adelaide and that a ban on organic waste to landfill is needed. Fig. 10 shows their responses to the questions about waste recycling and regulations.

3.2.2.4. Waste treatment. Thermal waste treatment technologies (such as incineration or gasification) are used to generate energy from waste. On one hand, waste-to-energy (wte) technologies generate energy and heat from waste; on the other hand, they deplete non-renewable resources. The local experts were asked whether Adelaide should promote or restrict thermal waste treatment technology as an emerging waste treatment solution.

Fig. 11 shows the participants' feedback on emerging waste treatment technology in Adelaide. 17 out of 24 experts stated that Adelaide should promote recycling rather than thermal waste treatment technology and around half of the experts also said Adelaide should put restrictions on future application of wte technology.

3.2.2.5. Waste disposal. Landfill is one of the most primitive and widely implemented waste management systems on earth. Adelaide has also depended on landfill. To achieve zero waste goals in Adelaide, certain disposal strategies should be considered in the future. Fig. 12 shows the experts' feedback on waste disposal systems in Adelaide. Even though half of the experts agreed that different initiatives should be implemented to achieve a 100% diversion to landfill, very few of them agreed that Adelaide should put restrictions, a ban or impose higher taxes on landfill use, on the contrary, they disagreed with both restriction and a higher landfill tax.

3.2.2.6. Waste management policy. Extended Producer Responsibility (EPR) is an important strategy for making industries accept responsibility for their end-of-life products. Fig. 13 shows the experts' feedback on such schemes – most strongly agreed with implementing EPR regulations and take-back schemes in Adelaide. They also agreed on imposing cradle-to-cradle design policy under EPR schemes.

3.2.2.7. Zero waste. Zero waste is a new concept that many cities would like to implement. Adelaide has also been implementing a zero waste strategy. Experts were asked whether information about and programmes on zero waste are available to people in Adelaide and whether zero depletion should be the key principle of zero waste strategy or not. Fig. 14 shows their feedback on the zero waste concept. Around half of the participants agreed that zero depletion should be a zero waste principle. However, mixed feedback was received about providing information and zero waste programmes.

3.2.2.8. Key priorities. The survey asked respondents to rate the emerging priority areas for waste management systems in Adelaide. Fig. 15 shows the frequency of feedback on key priority areas for future waste strategy. Ten priority areas were set and respondents were asked to rank them their priority on a 5-point scale from 'not important' to 'extremely important'.

Nearly 90% of all experts rated behaviour change, community participation, optimum recycling and recovery, producer and consumer responsibility, cradle-to-cradle design and creating a market for waste as either very important or extremely important emerging priority areas. The rest of the areas, such as reliable waste data for assessment, rules and regulation, shared ownership and public awareness, were rated as moderately important to very important by the waste experts.

3.3. Roadmap for a zero waste Adelaide

There is no straightforward path for a solution to current waste problems. On one hand, the consumption of resources has been increasing over time and hence, the generation of waste has also been rising (from Table 3). On the other hand, cities like Adelaide have set themselves the target to become zero waste cities despite continuous increasing per capita waste creation. Therefore, without a comprehensive and strategic roadmap, the zero waste goals may not be achieved in the desired timeframe. Despite some achievements in zero waste goals particularly in higher recycling and diversion rates, a comprehensive waste strategy is required to

Fig. 9. Frequency of respondents' agreement and disagreement on waste collection statements.

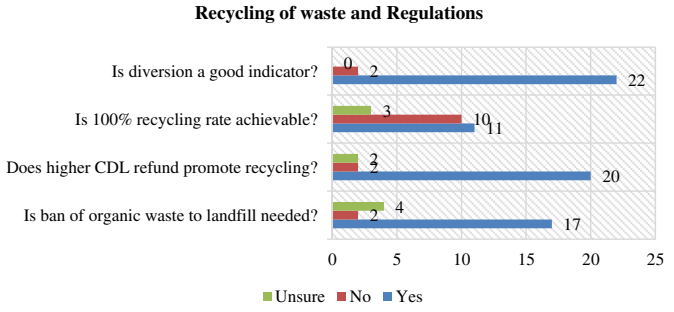

Fig. 10. Frequency of respondents' feedback on waste recycling and regulations.

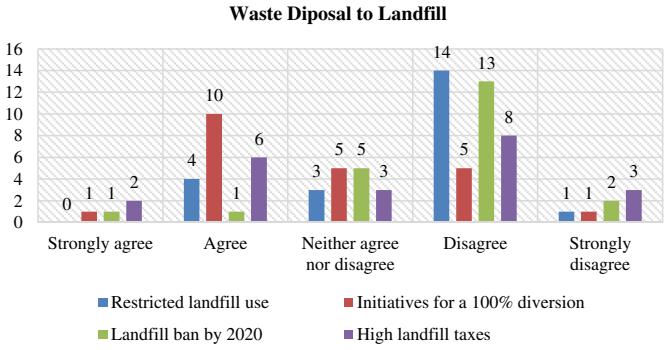

Fig. 12. Frequency of feedback on disposal of waste to landfill.

achieve the zero waste goals in Adelaide. The first section of the study measured the performance of waste management systems through the Zero Waste Index which indicated that the overall material recovery, energy and water savings has increased since 2003. The projected Zero Waste Index in Adelaide in 2020 is measured as 0.45 (around 45% material substitution from waste) which does not constitute significant progress when compared to ZWI = 0.32 in 2003. The second section of the study (questionnaire survey) identified the key priority areas and future action plans based on the views of local waste experts in metropolitan Adelaide. Hence, the study identified some selected priority areas for waste management systems in Adelaide based on an assessment of their current performance, projections for their future and a survey of experts. The following priority areas need urgent consideration for Adelaide to attain zero waste status.

- *Education and awareness:* increasing education and awareness are fundamental ways to combat current waste problems. To challenge waste problems, we need to improve our understanding of waste through proper education and raise awareness of waste. Enhancing education and awareness among the general public requires long term policies such as waste education being part of the school curriculum and implementing community engagement programmes that explain the benefits of product reuse and highlight the burdens of environmental pollution. Sustainable consumption behaviour is another important aspect of sustainability education. The increasing amount of waste is a direct outcome of unsustainable modern consumerism. Hence to tackle the creation of unnecessary waste we need to transform our unsustainable consumption behaviour into sustainable consumption behaviour. To foster sustainable consumption behaviour, the commitment of individuals, community groups, industries, corporations, businesses, government, and non-government organisations is essential to make the transformation successful. Metropolitan Adelaide has to develop an effective and long term awareness and education programme.
- *Zero waste management:* The traditional concept of waste as something produced at the end of our consumption activities has to be challenged by the new, zero waste concept. In the zero waste concept, waste is considered as a transitional phase of resources which can be taken back to the production process or disposed of to landfill. Hence zero waste management systems include product design, consumption, and resource recovery phases. Zero waste products, based on cradle-to-cradle design principles, would eventually not produce any waste during their production stages. At the end of product stage, the lifespan of the product should easily be extended by repair and thus be ready for reuse again. If not, then the product would be dematerialized to reprocess in the creation of a new product. If dematerialization is not possible, then the production process needs to be changed to make it more resource efficient. Finally the non-usable product would be recovered from the household waste stream and diverted from landfill. The zero waste management concept thus integrates both production of products and management of their end-of-life. Therefore, an extended producer and consumer responsibility is very important in zero waste management. Implementing producers' take-back schemes is an effective resource recovery strategy being applied in many countries.
- *Waste treatment and disposal:* waste treatment and disposal is another key area on the zero waste roadmap. The technology that we use in waste management systems (such as biological and thermal treatment technology) has affected overall waste management systems. The Zero Waste Index shows that resource substitution is maximized through reuse or recycling rather than incineration of waste. Incineration of waste may generate heat and energy but the resources that could

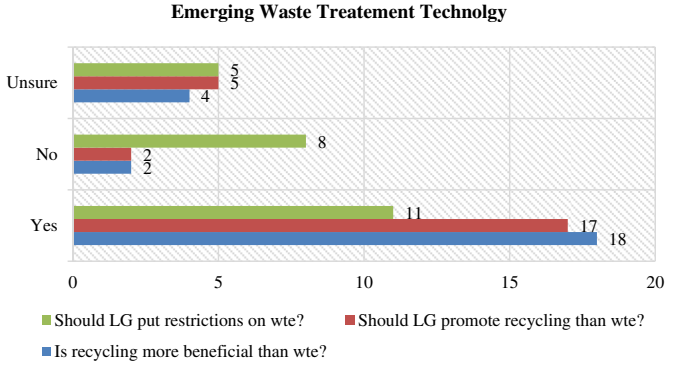

Fig. 11. Frequency of feedback on emerging waste treatment technology.

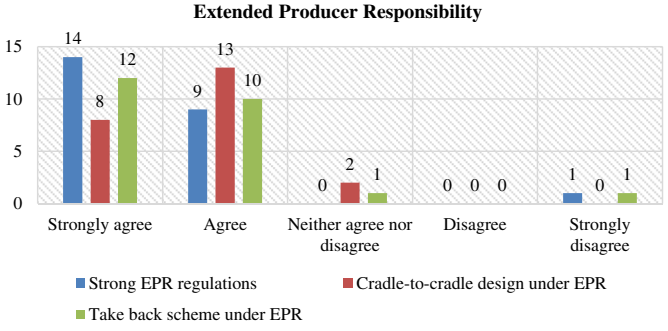

Fig. 13. Frequency of feedback on Extended Producer Responsibility.

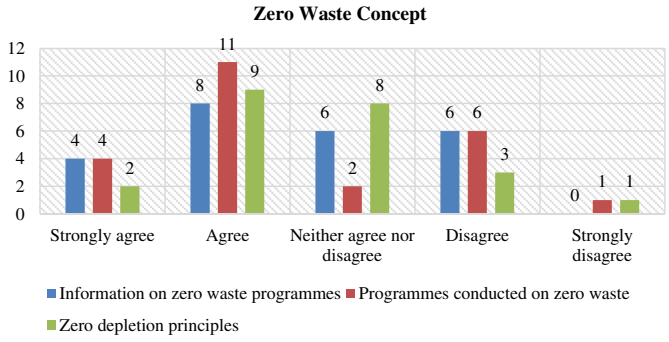

Fig. 14. Frequency of feedback on zero waste.

potentially be recovered are permanently depleted by the mass burn (incineration) systems. Landfilling waste similarly depletes resources and emits GHG in the atmosphere. Therefore, while thermal treatment and landfill may be temporary waste management solutions, for a permanent and zero waste solution these technologies need to be transformed into zero incineration and no-landfill systems by implementing long term zero depletion principles. Systems for sorting and collecting hazardous household waste (such as batteries, light bulbs and paint, and small electronic items) need to be improved because all of these hazardous wastes currently go to Adelaide's landfill sites. Without improving current systems, the overall pollution from waste will not be reduced despite a higher diversion of waste from landfill.

- *Regulatory strategies:* regulatory strategies are important for sustainable waste management. Regulatory strategies have long been used to encourage or limit certain mass burn technologies. For instance, laws that restricted disposal of organic, combustible and hazardous waste to landfill imposed higher landfill taxes and provided more incentives would encourage optimum resource recovery. CDL has been a successful policy in Adelaide and restricted waste disposal may encourage the development of waste treatment technology such as composting and anaerobic digestion. The plastic bag ban reduced the creation of plastic bag related-waste in Adelaide. From the survey waste experts in Adelaide believe that restriction of organic waste to landfill would encourage higher composting and resource recovery and boosting local anaerobic digestion technology in Adelaide.
- *Governance and infrastructure:* experts often observe that an effective waste management system reflects good governance. Zero waste governance requires new management approaches and infrastructure. A combination of effective 'hard' and 'soft' infrastructure is required to ensure optimum service to society. Waste collection, storing, sorting and recycling, treatment and disposal facilities are 'hard' infrastructures. Education, regulations and financial systems are 'soft' infrastructures. Community-based waste recycling centres, hazardous waste collection systems and separate waste collection for optimum recycling systems are priority areas for governance and infrastructures. A centralised waste data recording system with time series waste data is very important to analyse, assess and measure the performance of waste management systems. Community recycling centres are identified as priority areas for waste recycling of hazardous, non-hazardous and bulk waste. Dedicated community recycling centres would be drivers for promoting recycling of various waste streams in Adelaide.
- *Market creation:* our current globalized economy is predominantly driven by market systems. Since waste is part of everyday life, market-driven waste management solutions are vital to improve current waste management systems. In a positive market situation, waste management is easier and more cost-effective than in a negative market situation. In most of the developed countries, due to high labour and recovery costs waste is sent to developing countries by accepting the negative consequences of resource and environmental depletions. South Australia's CDL scheme promotes recycling by its refund policy. The South Australian government is committed to promoting waste recycling industries in Adelaide. Local recycling and reprocessing industries should play a vital role in waste management and the local economy.
- *Adaptive zero waste strategy:* any zero waste strategy should be adaptive and flexible to implement. Therefore, rather than very firm and short term policies; zero waste requires flexible and long term waste management strategies. The long term vision may be subdivided into short term targets and milestones. Current globalization systems are unpredictable due to diverse socioeconomic, geopolitical and environmental complexities. Local and decentralised waste management systems may be affected by global economic or environmental factors. The volume of waste exported and imported may be affected by local waste strategies. For instance, due to a higher recycling and incineration rate, Sweden is willing to import waste from neighbouring countries. Local waste management strategy can influence national waste management systems and vice versa. Therefore, the zero waste strategy should predict possible future consequences and be adaptive in nature.

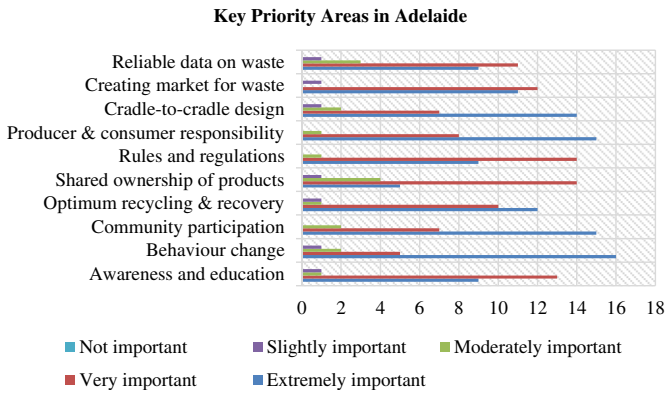

Fig. 15. Frequency of feedback on key priority areas for future waste strategy.

4. Conclusion

The study is a time series measurement of waste management performance in Adelaide based on the Zero Waste Index tool. From the assessment analysis, the study concludes that despite a potentially higher diversion rate (82.5%) in 2020, Adelaide may not be significantly advanced in virgin materials substitution and resource recovery by then and the projected ZWI would be 0.45. Zaman and Lehmann's (2013) study shows that in 2010 San Francisco achieved a 72% waste diversion rate with a ZWI of 0.51. This suggests that without a strategic waste recovery policy Adelaide may not achieve in 2020 what San Francisco achieved in 2010. Due to the global economic crisis and downturn, the waste market has also been facing significant economic and strategic challenges in Adelaide. Hence a strong, market-driven waste policy is urgently required.

Zero Waste SA is a key governing body in Adelaide and the city has been recognised as a world leader in waste management systems by implementing a zero waste strategy. Despite many

achievements such as an increasing diversion rate, considerable investment in waste infrastructures, restricted regulations, waste education at the primary school level and best management practices, Adelaide needs to wait for a longer period to see real achievement in zero waste management. Reliable waste data is very important for assessment and policy development and decision-making processes. Data about Adelaide's municipal solid waste is complex and has broad categories. The lack of reliable municipal waste data may make forecasting waste performance faulty. Therefore, Metropolitan Adelaide should give priority to central waste data collection systems to gather this information on a regular basis.

In conclusion, the study echoes UN-Habitat's (2010) statement that there is no single solution for complex waste problems. We need to consider the local context alongside the global market situation and adapt an optimum zero waste strategy through the active participation of all stakeholders. The identified key priority areas that are important focal points for future zero waste strategies in Adelaide include capacity building, waste management policy and strategy development and market structures.

Acknowledgement

This study is part of an on-going research project studying strategies for zero waste and urban material flows conducted at the Zero Waste SA Research Centre for Sustainable Design and Behaviour (sd+b) at the University of South Australia. The authors thank three anonymous referees for their insightful comments.

Appendix A. sample survey questions

1. Personal Information (name, affiliation, year of experiment, age, sex etc.)
2. Level of concern in environmental issues (not concern to very concern)
   - *Waste problem*
   - *Global climate change*
   - *Global sustainability*
3. Issues of awareness, education and behaviour change on waste (strongly disagree to strongly agree)
   - *Waste problems are partially created due to lack of awareness and proper education on waste*
   - *Awareness, education and willingness are the key drivers of the behaviour change*
   - *Local government should promote supplementary awareness and education programmes to communities.*
4. Issues related to waste avoidance (strongly disagree to strongly agree)
   - *Lack of awareness and willingness to recycle right potentially generate more waste that would otherwise be avoided*
   - *Busy lifestyle makes it hard to avoid waste generation*
   - *Innovative product design could potentially reduce the creation of waste at the first point of generation*
   - *Local government should take initiative to involve manufacturers for avoiding waste by innovative product design*
5. Issues related to waste collection (strongly disagree to strongly agree)
   - *Kerbside waste collection has higher recycling rates*
   - *Common community recycling place is more convenient than remotely located recycling depot*
   - *Local government should provide separate bins for compost, recyclable, hazard/e-waste and non-recyclable*
   - *Kerbside waste collection is costly, therefore, citizen should grant waste tax to provide better collection services*
6. Issues related to waste recycling and regulatory policy (Yes, No, Unsure)
   - *Do you think, diversion of waste from landfill is a good indicator to measure the performance of waste management systems in your city?*
   - *Is 100% recycling rate achievable by raising awareness and providing adequate infrastructure?*
   - *Container Deposit Legislation is successful in many cities; do you think higher amount of container refund systems would potentially increase recycling rates?*
   - *Many cities ban organic waste to landfill, do you think restriction on organic waste to landfill would increase composting or anaerobic digestion?*
7. Issues related to emerging waste treatment technology in Adelaide (Yes, No, Unsure)
   - *Do you think reuse, recycling and composting are more beneficial than waste-to-energy technology such as incineration?*
   - *If recycling replaces virgin materials more than waste-to-energy technology, do you think local government should promote recycling more rather than waste-to-energy technologies?*
   - *Do you think local government should put restrictions on the waste-to-energy technology?*
8. Issues related to waste landfill (strongly disagree to strongly agree)
   - *Local government should ban landfill and seeks for alternative*
   - *Local government should take initiatives for a 100% diversion rate*
   - *Local government should ban landfill by 2020*
   - *Local government should impose high landfill taxes*
9. Issue related to management policy (strongly disagree to strongly agree)
   - *Cradle-to-cradle design initiative under EPR*
   - *Company should implement 'take back' scheme under EPR in their product supply chain*
   - *Local government should imposes EPR policies to the manufacturers*
10. Issues related to zero waste (strongly disagree to strongly agree)
    - *Information on zero waste programmes are available and easily accessible from the local government websites*
    - *A number of awareness programmes on zero waste are conducted by the local government*
    - *Zero depletion should be the key principle of the zero waste concepts*
11. Issues related to priority areas on zero waste strategy in Adelaide (not important to extremely important)
    - *Awareness and education*
    - *Behaviour change*
    - *Community participation*
    - *Cradle-to-cradle design*
    - *Creating market for recycling*
    - *Optimum recycling and recovery*
    - *Producer and consumer responsibility*
    - *Reliable data on waste*
    - *Rules and regulation on waste*
    - *Shared ownership of products*

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