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Session 2

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A comparison of international and Australian research on the disclosure of building performance for energy efficiency

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This paper has a primary focus on the economics of energy efficient housing and mandatory disclosure schemes. From this basis, this paper investigates the role and effect of regulations for the disclosure of the building performance of residential dwellings during the sale process in making energy efficiency visible to the market. The paper examined both international and Australian hedonic pricing analyses that unanimously find positive relationships between energy efficiency and sale price when building performance is disclosed to the market. The paper has also investigated international and Australian qualitative studies that investigate consumer attitudes to energy efficiency when building performance is disclosed during the sale process, many of which found that energy efficiency was not a primary concern compared to more traditional metrics such as location, price and size.

The paper has found that a far greater body of research into the impacts of mandatory disclosure regulations has been conducted internationally, especially throughout Europe where the Energy Performance of Buildings Directive (2002/91/EC) has established a common framework for Member States, allowing for comparative studies to be undertaken. On the other hand, limited implementation of disclosure regulations in select Australian States and Territories has limited the amount and breadth of research.

Understanding market reactions, in particular the value of environmental features and how the benefits of energy efficient housing are conveyed to the public will play a vital role in encouraging the private sector to pursue energy efficient measures going forward, contributing to the overall environmental sustainability of the residential sector.

Keywords: Research comparison; Mandatory disclosure; Energy efficiency, Building performance; Market impact.

Introduction

This paper will examine the body of international research in to the impact and effectiveness of regulations for the disclosure of the energy efficiency performance of residential buildings when sold to the market. The paper will first focus on international quantitative hedonic pricing analyses undertaken in a range of countries throughout Europe. The findings of these quantitative studies will then be compared to qualitative research undertaken in to whether energy efficiency ratings are appropriately advertised and considered important or trustworthy to home buyers across European countries.

The paper will then investigate Australian research in to the impacts of mandatory disclosure regulations that have been implemented in the Australian Capital Territory since 1999 (ACT Planning and Land Authority 2004) and a Sustainability Declaration scheme implemented in Queensland between 2010 and 2012 (Department of Housing and Public Works 2012). Findings of a detailed quantitative hedonic pricing analysis undertaken by the Australian Department of Environment, Water, Heritage and the Arts (DEWHA 2008b) will be compared with the findings of Australian qualitative research in to the importance placed on energy efficiency information by home buyers as perceived by real estate professionals and a theoretical laboratory based study (Bryant and Eves 2012; Burfurd, Gangadharan and Nemes 2012).

Whilst mandated requirements through the Building Code of Australia to increase the minimum NatHERS rating standards of newly built homes, from 4 stars in 2003, to 5 stars in 2006 and 6 stars in 2010, have resulted in significant reductions in household energy use whilst also delivering economic benefits (Moore 2010; Morrissey and Horne 2011; Ambrose et al. 2013; Australian Energy Market Commission 2013; Saddler 2013), regulations for the disclosure of energy performance during the sale process aim to create incentives for property owners to invest in the energy efficiency of their home, assist with purchaser knowledge and the ability of home buyers to differentiate and value the performance differences amongst properties, correct failures within the real estate market from asymmetrical or missing information and encourage the building industry to create new buildings above minimum energy performance standards (DEWHA 2008b).

In the context of widely accepted anthropogenic climate change (Stern 2006; Garnaut 2008) it is important to investigate ways to reduce the significant impact of residential housing on energy use and greenhouse gas emissions, with the Australian Greenhouse Office (2006) finding that the residential sector is responsible for 26 per cent of national emissions, with notable additional emissions due to the energy embodied in building materials.

International Research on the Disclosure of Building Performance

A significant body of research investigating the impacts of mandatory disclosure regulations on the choices and decision making processes of home buyers has been conducted internationally, particularly throughout Europe. Since the 16th of December 2002, Directive 2002/91/EC of the European Parliament and of the Council of the European Union on the Energy Performance of Buildings (EPBD) has provided European Union Member States with a framework 'to promote the improvement of the energy performance of buildings' (European Parliament and Council of the European Union 2003, 67). Article 7 of the EPBD requires that 'when buildings are constructed, sold or rented out, an energy performance certificate is made available to the owner or

by the owner to the prospective buyer or tenant...' (EPCEU 2003, 68). The objective of EPCs is for the provision of information to consumers, 'in order to make it possible for consumers to compare and assess the energy performance of the building' (EPCEU 2003, 68). Directive 2010/31/EU on the Energy Performance of Buildings revised the original 2002/91/EC Directive, including changes for the inclusion of the Energy Performance Indicator from the EPC in any advertisement in the commercial media for any building to be sold or rented (EPCEU 2010, 13).

Hedonic pricing analyses of the effect of the energy labelling of homes has confirmed price premiums for more highly efficient homes. Brounen and Kok (2011) found that homes in the Netherlands with an 'A' grade energy rating transact at a price premium of 10.2 percent as compared to similar homes with the intermediate 'D' grade, and dwellings with a low 'G' rating transact at a discount of some 5 percent. Kahn and Kok (2013) found in a study of 4231 Californian homes that were subject to energy labelling by a variety of certification organisations were subject to a 2-4 percent price premium in comparison to a sample of 1.6 million non-certified homes, taking in to account variable characteristics such as location and time of sale. In England, from a data set of 325,950 dwellings sold at least twice in the period from 1995 to 2011, Fuerst et al. (2013) found a clear positive relationship between house price and EPC ratings, estimating that compared to dwellings rated EPC G, dwellings rated EPC F and E sold for approximately 6 percent more, dwellings rated D sold for 8 percent more, dwellings rated C for 10 percent more and dwelling rated either B or A sold for 14 percent more. Hyland, Lyons and Lyons (2013) also found a positive relationship between the Building Energy Rating and house prices in Ireland, using a data set of 397,258 properties listed for sale and 888,211 properties listed for rent between 2008 and 2012 on Ireland's most popular real estate website. The results of this study found that if the BER is measured as a 15-point scale from A1 to G, each rating decline along the BER scale is associated with a reduction in price of 1.3 percent.

Whilst quantitative hedonic price analysis' have unanimously found positive relationships between house price and building performance when disclosed to the market, international qualitative research has been more sceptical of the disclosure of building performance. Murphy, Meijer and Visscher (2012) investigated the content, underlying theory and impact of the main policy instruments aimed at improving the energy performance of private dwellings in place in the Netherlands in 2010. The stakeholders interviewed agreed that problems regarding the methodology, presentation and professional accreditation of inspectors associated with the EPC in its initial introduction in the Netherlands in 2008 had negatively impacted on the schemes effectiveness, though it was believed that the effectiveness of EPCs would improve over time as consumer confidence increased and better enforcement regimes were introduced. Murphy, Meijer and Visscher (2012) found a paradox with dwellings of higher energy efficiency obtaining a market advantage whilst the EPC suffered from poor performance as a stimulus to improve energy performance.

A number of international studies have focussed on the extent of the disclosure of energy performance in advertising material and the impacts of this information on consumer decision making. Amecke (2012) found that the EPC had only played a limited role in the purchasing decisions of 622 German home buyers due to EPCs only being available for a minority of dwellings, a lack of trust in the information provided, the failure of EPCs to display the financial implications of energy efficiency and due to energy efficiency being a secondary concern to traditional housing metrics such as location, price and outdoor space.

In a comparative study of the reporting of energy efficiency in Norway, Sweden and the UK using theories of the performativity of economics Aune (2012) found that energy related issues were presented in 79 percent of British advertisements, 39 percent of Swedish advertisements and only 4 percent of Norwegian advertisements through the comparison of 1710 online housing advertisements. Watts, Jentsch and James (2011) found that 87 percent of dwellings advertised during this period disclosed energy performance information, whilst 67 percent of home buyers received an EPC before purchasing their home. Aune (2012) concluded that the results indicate that minimal disclosure of energy related issues, especially when presented as secondary to traditional metrics, are likely to be insufficient to make energy a matter of concern in the home buying process.

Watts Jentsch and James (2011) found that location, size and price were the most important factors for home buyers, with energy efficiency being the least important of building metrics in the home buying process. A majority of home buyers reported that the EPC did not have an effect on price negotiations or the decision to buy a home, though the EPC was useful for explaining energy efficiency. For Watts, Jentsch and James (2011) it was not clear whether the information and ratings contained in the EPC would have a significant effect on the value of dwellings, as the interaction of other more traditional home metric were viewed as more important than energy efficiency, creating more complex considerations than in the purchase of other energy labelled items, such as home appliances.

Gram-Hanssen et al. (2007) also conducted a comparative study investigating how households receive, interpret and react to energy labels and assessments in Denmark, where a successful energy labelling scheme has been in place since 1997, and Belgium, where energy labelling was established under the EPBD in 2006 and subject to a voluntary trial scheme at the time of research. Gram-Hanssen et al. (2007) found that first hand interaction between the home buyer and the home assessor was paramount to the understanding and trust of the energy label and that the discussion and confirmation of this assessment amongst the buyer's social network played an important role in the acceptance of this advice.

Australian Research on the Disclosure of Building Performance

Since the 31st of March 1999, the Australian Capital Territory has had in operation a scheme for the mandatory disclosure of the energy ratings of existing dwellings. This legislative framework initially came into effect under the *Energy Efficiency Ratings (Sale of Premises) Act 1999* (ACT) and was subsequently continued by the *Civil Law (Sale of Residential Property) Act 2003* (ACT). The legislation requires the disclosure of the Energy Efficiency Rating (EER) to consumers in all advertising material and the supply of the full certificate when the sale is transacted, with this certificate indicating the possible energy performance improvements specific to the building (DEWHA 2008b). The EER is the ACTHERS rating of the house, which indicates the thermal performance of the house on a scale of 0 to 10 stars, where 0 is low and 10 is high thermal performance (ACT Planning and Land Authority 2004).

Similarly to Kahn and Kok (2013), Brounen and Kok (2011), Fuerst et al. (2013) and Hyland, Lyons and Lyons (2013), a hedonic analysis of the relationship between the EER of houses and house prices in the ACT was undertaken by the Australian Bureau of Statistics under the commission of the Department of the Environment, Water, Heritage and the Arts in 2007 (DEWHA 2008b). The DEWHA's (2008b) study is the only Australian study to examine the value of NatHERS Star ratings on the market

value of residential properties. The study comprised of a data set of 5,104 homes sold over a two year period over the years 2005 and 2006, with these years chosen to reduce the influences of start-up issues with the regulations on the data. The study found that the EER makes up a small part of the total value of a house, with block and house size and location having a greater influence on house price than energy efficiency. However, there was a significant positive relationship between the EER and house price, where 'the association on average for 2005 was 1.23 percent for each 0.5 EER star and 1.91 percent in 2006, holding all other variables constant' (DEWHA 2008b, 6). Similarly to Fuerst et al. (2013), who found that nearly 93 percent of dwellings sold in England are in EPC bands C, D and E, with 45.5 percent in band D, DEWHA (2008b) found that the average NatHERS rating of existing homes in the ACT was just below 1.7 stars, indicating generally low thermal efficiency standards of existing housing.

Similarly to the international qualitative research, Bryant and Eves (2012) questioned the effect of the disclosure of building performance on sale price and home buyer decision making in a two week long study of real estate advertisements and a voluntary survey of 587 real estate professionals in Queensland, finding that despite widespread compliance with mandatory disclosure legislation enforced from January 1st 2010, 96 per cent of homebuyers did not consider the Sustainability Declaration as an important factor in their decision-making process. Unlike other studies, such as DEWHA (2008b) where the research was undertaken 6 years after disclosure regulations were introduced in order to avoid biases caused by start-up issues and market adjustment periods, Bryant and Eve's (2012) study was undertaken in the first year of the operation of disclosure regulations in Queensland and, as such, consumers may have been unaware of the operation of these regulations.

Burfurd, Gangadharan and Nemes (2012) used a ‘laboratory’ oriented approach to investigate the impact of mandatory and voluntary disclosure and minimum upgrade policies on residential rental markets, concluding that mandatory disclosure of energy efficiency to potential lessors delivered greater performance in terms of efficiency and higher rates of tenancy than the current status-quo scenario, indicating more assured and confident market places. A regulated approach towards minimum upgrades (such as the current BCA requirements) resulted in higher average upgrade levels but a decline in the number of properties available.

In South Australia, long-term environmental policies for the mitigation of climate change are contained within ‘Tackling Climate Change: South Australia’s Greenhouse Strategy 2007 – 2020’. Strategy 2 for Improved Building Performance within the South Australian Government Action Plan to 2012, contained within the Tackling Climate Change strategy, aimed to ‘establish a consistent approach to mandatory measuring, monitoring and disclosure of building energy consumption performance and the impact of occupant behaviour’ (Government of South Australia 2007, 65). Efforts were made to introduce a national mandatory disclosure scheme for the building energy, greenhouse and water efficiency performance of residential buildings at the time of sale or lease under the Rudd Labor Government, with a regulatory impact statement released in anticipation (Allen Consulting Group 2011). This scheme was agreed to by South Australia as part of the Council of Australian Government (COAG) in April 2009, with implementation due to commence in May 2011 (Bryant and Eves 2011). However, with rising government expenditure the scheme was abandoned under the Gillard Labor Government.

Research Summary and Identification of Gaps in the Literature

A review of the international and Australian research establishes a number of major agreements on the need for and growing cost effectiveness of energy efficient housing. The findings of the review are summarised in Table 1 below:

Table 1: Overview of International and Australian Research.

Country	Author	Type of Research	Findings
Netherlands	Brounen and Kok (2011)	Hedonic price analysis	Homes with an 'A' grade energy rating transact at a price premium of 10.2 percent compared to homes with a 'D' grade, dwellings with a 'G' rating transact at a discount of 5 percent.
England	Fuerst et al. (2013)	Hedonic price analysis	Compared to dwellings rated EPC G, dwellings rated F and E sold for approximately 6 percent more, dwellings rated D sold for 8 percent more, dwellings rated C for 10 percent more and dwelling rated either B or A sold for 14 percent more.
Ireland	Hyland, Lyons and Lyons (2013)	Hedonic price analysis	Each rating decline along the BER scale is associated with a reduction in price of 1.3 percent.
United States of America (California)	Kahn and Kok (2013)	Hedonic price analysis	Homes subject to energy labeling were subject to a 2-4 percent price premium.
Australia (ACT)	DEWHA (2008b)	Hedonic price analysis	Each 0.5 EER star incurred a price premium of 1.23 percent in 2005 and 1.91 percent in 2006.
Norway, Sweden and the UK	Aune (2012)	Analysis of housing advertisements	Minimal disclosure of energy related issues, especially when presented as secondary to traditional metrics, are likely to be insufficient to make energy a matter of concern in the home buying process.
Denmark and Belgium	Gram-Hanssen et al. (2007)	Qualitative interviews with home buyers	First hand interaction between the home buyer and the home assessor increases understanding and trust of the energy label.
Germany	Amecke (2012)	Qualitative interviews with home buyers	The EPC had only played a limited role in purchasing decisions.

Country	Author	Type of Research	Findings
England	Watts, Jentsch and James (2011)	Qualitative surveys sent to home buyers	Energy efficiency not a primary concern for home buyers. EPC had minimal impact on sale price or price negotiations and the decision to buy.
Australia (Qld)	Bryant and Eves (2012)	Qualitative survey sent to real estate professionals	96 per cent of homebuyers did not consider the Sustainability Declaration as an important factor in their decision-making process.
Australia (Vic)	Burfurd, Gangadharan and Nemes (2012)	Laboratory study	Enabling landlords to advertise the energy efficiency of their properties increases investment in energy efficiency.

All hedonic analyses have reported a positive relationship between energy performance and price when the energy performance of buildings is disclosed, while qualitative data indicates varying levels of understanding and acceptance of the energy efficiency information disclosed. These variances have both positive and negative implications in the debate about the value of implementing regulations for the disclosure of building performance. In some ways the qualitative data supports the quantitative hedonic pricing analyses, as although the qualitative data finds that energy efficiency remains a secondary concern to home buyers compared to location, size and price, energy efficiency is still taken in to account to some extent in the final purchase, resulting in a small price premium that should act as an incentive for home owners to improve the energy efficiency of their dwelling before its sale. However, the qualitative data rarely refers to the existing quantitative studies in this way and, as such, the qualitative data can understate the value of regulations for the disclosure of building performance, discouraging policy makers from implementing such regulations. Regardless, these varying research findings add depth to the information available about disclosure regulations and greater research, particularly in Australia, would be of value in informing future policy debate.

The issue of mandatory disclosure is a salient one given that in November 2014 the National Energy Efficient Building Project, which was commissioned by the South Australian Government's Department of State Development on behalf of the Australian Government and all States and Territories, found that consumers are not reported to value energy efficiency highly, reflecting a deficit of knowledge. As a result, the implementation of policies for the mandatory disclosure of building energy performance were recommended in the hope of improving the accountability of the building supply chain and making the performance outcomes of buildings more transparent to consumers (Pitt & Sherry 2014). This represents the early signs of future policy shifts, which are significant given the failure of the implementation of a national mandatory disclosure scheme in 2011.

Australian research on the impact of mandatory disclosure regulations is significantly underdeveloped in comparison with existing body of international literature. Previous research in Australia has investigated the effects of the disclosure of energy ratings on home values (DEWHA 2008b; Berry, Marker and Chevalier 2008) and buyer and seller awareness (Bryant and Eves 2011) in individual states, but not comparatively across

states. A comparative study on the voluntary and mandatory disclosure of building performance across Australian States would provide an insight in to what effect the disclosure of energy efficiency ratings has on the awareness, understandings and values placed on building performance ratings by home buyers and real estate professionals in different market environments, where energy efficiency is mandatorily disclosed and where it is not.

References

ACT Planning and Land Authority. 2004. “ACT House Energy Rating Scheme (ACTHERS).” ACT Residential Guidelines. Accessed June 17 2014. http://apps.actpla.act.gov.au/tplan/planning_register/register_docs/acthers_guide.pdf.

Allen Consulting Group. 2011. “Mandatory Disclosure of Residential Building Energy, Greenhouse and Water Performance: Consultation Regulation Impact Statement.” fourth draft report to the National Framework for Energy Efficiency Building Implementation Committee, March.

Amecke, Hermann. 2012. “The impact of energy performance certificates: A survey of German home owners.” *Energy Policy,* 46:4-14.

Aune, Margrethe. 2012. “Making energy visible in domestic property markets: the influence of advertisements.” *Building Research and Information,* 40:6:713–23.

Australian Energy Market Commission. 2013. “Strategic Priorities for Energy Market Development.” Australian Energy Market Commission, Sydney.

Australian Greenhouse Office. 2006. “Scoping study to investigate measures for improving the environmental sustainability of building materials.” Commonwealth of Australia, Canberra.

Berry, Stephen, Marker, Tony and Tom Chevalier. 2008. “Modelling the relationship between energy efficiency attributes and house price: The case of detached houses sold in the Australian Capital Territory in 2005 and 2006.” *World Sustainable Buildings Conference,* Melbourne.

Brounen, Dirk and Nils Kok. 2011. “On the economics of energy labels in the housing market.” *Journal of Environmental Economics and Management*, 62:2:166-79.

Bryant, Lyndall and Chris Eves. 2012. “Home sustainability policy and mandatory disclosure; A survey of buyer and seller participation and awareness in Qld.” *Property Management*, 30:1:29-51.

Building Energy Efficiency Disclosure Act 2010 (Cth).

Burfurd, Ingrid, Gangadharan, Lata and Veronika Nemes. 2012. “Stars and standards: Energy efficiency in rental markets.” *Journal of Environmental Economics and Management*, 64:2:153-68.

Department of the Environment, Water, Heritage and the Arts. 2008a. “Energy Use in the Australian Residential Sector 1986-2020.” Commonwealth of Australia, Canberra.

Department of the Environment, Water, Heritage and the Arts. 2008b. “Energy efficiency rating and house price in the ACT.” Commonwealth of Australia. Canberra.

Department of Housing and Public Works. 2012. “Building and Plumbing Newsflash 506: Withdrawal from COAG commitments for 6-star units and a Residential Building Mandatory Disclosure scheme.” Building Codes Queensland. Accessed January 24

2015. http://www.hpw.qld.gov.au/SiteCollectionDocuments/Newsflash506WithdrawlFromCOAGCommitmentsForSixStarUnits.pdf.

European Parliament and Council of the European Union (EPCEU). 2003. "Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)." Official Journal of the European Communities 4.1.2003:65-71.

European Parliament and Council of the European Union (EPCEU). 2010. "Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings." Official Journal of the European Union 18.6.2010:13-35.

Fuerst, Franz, McAllister, Pat, Nanda, Anupam and Peter Wyatt. 2013. "An investigation of the effect of EPC ratings on house prices." Department of Energy and Climate Change, UK. 17 June 2013. Accessed February 3 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/207196/20130613_-_Hedonic_Pricing_study_-_DECC_template__2_.pdf.

Garnaut, Ross. 2008. *The Garnaut climate change review: final report*. Port Melbourne:Cambridge University Press.

Government of South Australia. 2007. "Tackling Climate Change: South Australia's Greenhouse Strategy 2007 – 2020." Adelaide, South Australia.

Gram-Hanssen, Kirsten, Bartiaux, Francoise, Jensen, Ole Michael and Madeleine Cantaert. 2007. "Do homeowners use energy labels? A comparison between Denmark and Belgium." *Energy Policy,* 35:2879-88.

Hyland, Marie, Lyons, Ronan C. and Sean Lyons. 2013. "The value of domestic building energy efficiency — evidence from Ireland." *Energy Economics*, 40:943-52.

International Energy Agency 2012, "*World Energy Outlook 2012."* International Energy Agency:Paris.

Kahn, Matthew E. and Nils Kok. 2013. "The capitalization of green labels in the California housing market." *Regional Science and Urban Economics*. 47:25-34.

Moore, Trivess. 2010. *"The costs and benefits of zero emission housing: modelling of single detached houses in Melbourne."* RMIT University:Melbourne.

Morrissey, J. and R. Horne. 2011. "Life cycle cost implications of energy efficiency measures in new residential buildings." *Energy & Buildings*, 43:4:915-24.

Murphy, Lorraine, Meijer, Frits and Henk Visscher. 2012. "A qualitative evaluation of policy instruments used to improve energy performance of existing private dwellings in the Netherlands." *Energy Policy,* 45:459–68.

Pitt & Sherry. 2014. "*National Energy Efficiency Building Project."* Swinburne University of Technology. Government of South Australia – Department of State Development. November 2014.

Saddler, Hugh. 2013. "*Power Down: Why is electricity consumption decreasing?*." The Australia Institute:Canberra.

Stern, Nicholas. 2006. "*The Stern review on the economics of climate change*." HM Treasury:London.

Watts, Christabel, Jentsch, Mark F. and Patrick AB. James. 2011. “Evaluation of domestic Energy Performance Certificates in use.” *Building Services Engineering Research & Technology*. 32:4:361-76.

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Waste Management Practices in Construction Projects: Perceptions of Project Managers

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Natural and built environments

The construction industry has been found to be a major generator of waste and there are many challenges associated with finding the most sustainable way to manage construction waste. As the construction industry is a project based industry, it is essential to look at cultural issues related to waste management at the project level. Therefore, this research aims to identify the current status of waste management practices in construction projects by analysing project managers' views on waste management performance in construction projects; project managers' attitudes towards waste management; and project managers' views on waste management culture in construction projects. A questionnaire survey was carried out and project managers were selected as a target group to distribute questionnaires, as project managers have a vital involvement in promoting and maintaining project culture in the construction project environment. Data was analysed using descriptive statistics and the Kruskal-Wallis test. The findings reveal that project managers believe that even though the operational cost of waste minimisation is high in construction projects, overall waste management is profitable. At the same time it was interesting that even though project managers believe most project participants are satisfied with existing waste management systems, overall waste management efforts are not perceived as being at a satisfactory level in construction projects. Project managers consider waste as an inevitable by-product, but they do not believe that waste management is beyond the control of project members or that waste has no value. At the same time, it was found that project managers infer that project participants are cost and time conscious in waste management despite the roles, responsibilities and duties of each party in waste management not being well-coordinated or fully understood. Taken together, these findings highlight the misconceptions related to waste management in construction projects and emphasise the necessity of collective responsibility on the part of project participants to enhance the performance of waste management in construction projects.

Keywords: Waste management, Attitudes, Performance, Culture, Project managers

Introduction

Acknowledging the ambiguities associate with any comprehensive waste definition, Pongrácz and Pohjola (2004) advocate that labelling something as 'waste' refers more to the fact that something is treated as 'waste' rather than the properties of the object itself. A similar argument was made by Moser (2007) with regards to acknowledging the cultural construction of 'garbage' in that the concept is defined and acknowledged in different ways by different systems. Thus it can be argued that what is considered as 'waste' in one system may be culturally valued in another system. In the construction context Shen et al. (2004, 473) defined construction waste as,

Building debris, rubble, earth, concrete, steel, timber, and mixed site clearance materials, arising from various construction activities including land excavation or formation, civil and building construction, site clearance, demolition activities, roadwork, and building renovation.

The above definition is used in this research to define waste in the context of building construction. Construction waste generation is considered as a major problem in the construction industry due to its negative impacts on the environment and economy (Dajadian and Koch 2014). When it comes to the Australian context, the construction industry was the largest waste generator during 2009-2010 and produced 16.5 million tonnes of waste, which is 31% of total waste generation (Australian Bureau of Statistics 2013). In 2011 it was found that construction and demolition waste contributed around 25.8% of overall landfill (Australian Bureau of Statistics 2011). The following graph shows per capita construction and demolition waste disposal and recycling in each state of Australia (excluding the ACT).

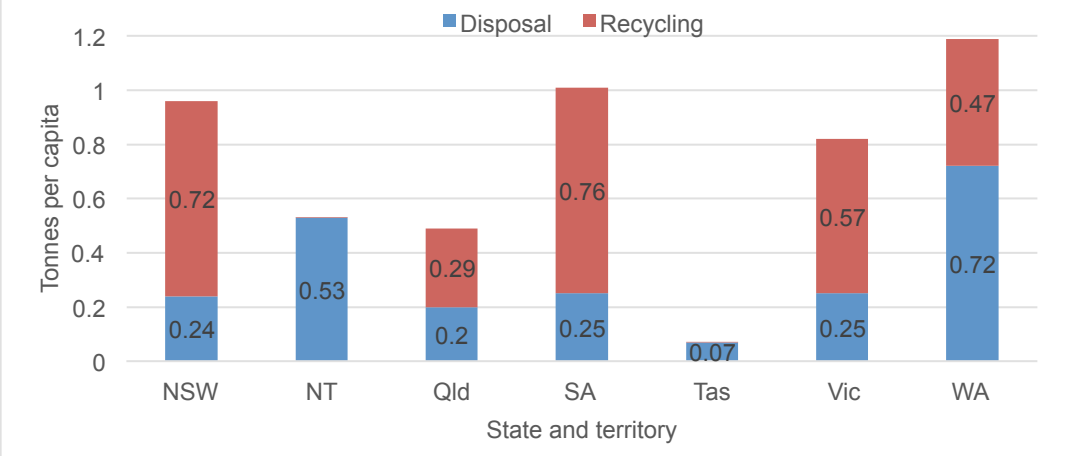


Figure 1: Per capita waste generation for each state and territory (excluding the ACT), 2010-11 (Australian Government 2013)

As shown in the figure 1, South Australia and New South Wales have high construction waste recycling rates and relatively low waste disposal rates comparing to other states and territories. However, overall waste management (WM) is not at a satisfactory level there is still plenty of room for improvement in Australia as highlighted above. As pointed out by McDonough and Braungart (2009) prevailing cultural beliefs and attitudes have lead many people to believe that they can throw things away once finished with them. However, McDonough and Braungart (2009, 27) point out that "away" does not really exist and "away" has gone away. Since culture governs the behaviour expected and acceptable by members (Gray 2001), it is necessary to identify the ideal cultural environment for waste elimination and/or minimisation. Even though there are a large number of publications around the concepts of waste generation,

waste reduction, waste reuse, waste recycling, and WM in general, globally there are very few research studies on the human factors related to WM (Yuan and Shen 2011). Thus, this research was designed to fill this research gap to identify the current status of WM in Australia by analysing project managers' (PMs') views on WM performance in construction projects; PMs' attitudes towards WM; and PMs' views on WM culture in construction projects.

Literature review

Researchers have asserted that construction practitioners are more focused on profit maximisation than reducing the environmental impacts of construction actions (Wong and Yip 2004, Yuan and Shen 2011). However, the environmental impacts of development decisions cannot easily be equated with monetary value (Graham and Smithers 1996). Johnston and Mincks (1995) argued that a false assumption exists among construction practitioners that time spent on managing construction waste is a loss of productivity and pointed out that the construction industry should see WM as a profitable venture. Supporting this view, Innes (2004 cited in Osmani, Glass, and Price 2008) reported that with the implementation of construction WM plans, construction projects can gain 3% of cost saving without significant investment. Construction WM plans help to provide such cost benefits due to: cost reduction in material purchasing (Jaillon, Poon, and Chiang 2009, Bossink and Brouwers 1996, Coventry and Guthrie 1998, Manowong 2012), transportation costs of materials and waste (Jaillon, Poon, and Chiang 2009, Coventry and Guthrie 1998), waste minimisation (Johnston and Mincks 1995), waste disposal and tipping costs (Johnston and Mincks 1995, Bossink and Brouwers 1996, Coventry and Guthrie 1998). Effective WM has social and environmental benefits in that it reduces the need for landfill area along with the health risks related to waste disposal (Lingard, Graham, and Smithers 2000). As proper WM reduces resource extraction, Lingard, Graham, and Smithers (1997) pointed out that reducing waste at its source is better than recycling once it is generated. Thus, it is necessary to encourage the construction industry to employ cradle-to-cradle construction methods which produce no waste as they are based on the closed-loop nutrient cycles of nature (McDonough and Braungart 2003).

As described by Dainty, Green, and Bagilhole (2007, 3), the construction project environment consists of 'diverse groups of people who are brought together for short periods of time and are expected to rapidly establish cooperative working relationships while frequently being engaged on entirely different terms and conditions'. Recent evidence suggests that the continuous changing mix of project members, along with the complex and unique nature of project setting, leads to a complex mix of attitudes and beliefs across construction project teams (Brewer and Gajendran 2010). Thomas et al. (2002) highlighted that each time a new project is created, it is necessary to form new sets of relationships and it increases the demand for social management skills, though this is often not adequately acknowledged and appreciated. Thus, the construction industry has suffered due to its poor performance in relation to employment practices and industrial relations for a long time (Dainty, Green, and Bagilhole 2007). Researchers have argued that poor performance in people management in the construction industry can be eliminated by addressing cultural issues in construction (Dainty, Green, and Bagilhole 2007, Ochieng and Price 2010). Hence, there is on-going debate on the ideal cultural environment for optimum performance (Gray 2001). When project members bring their own culture to the team, those cultures inform the development of basic decision making processes (Sousa-Poza and Henrie 2005). Burke (2007) stated that the PM holds a singular point of responsibility and guides all

contributors for successful completion of a project by integrating and coordinating all contributions. Therefore, the development of optimum project culture in construction projects is one of the important tasks of PMs (Riley and Clare-Brown 2001, Anderson 2003). In the construction context, the importance of human factors in waste has gained more attention from 2008 onwards, as researchers started to identify that the best solutions for construction WM depends on practitioners rather than waste material itself (Yuan and Shen 2011). Hardie et al. (2007) also identified that correct attitudes are crucial in achieving sustainable WM practices in construction projects. Thus, it is necessary to understand attitudes and behaviours towards WM to effectively manage waste in construction projects (Begum et al. 2009).

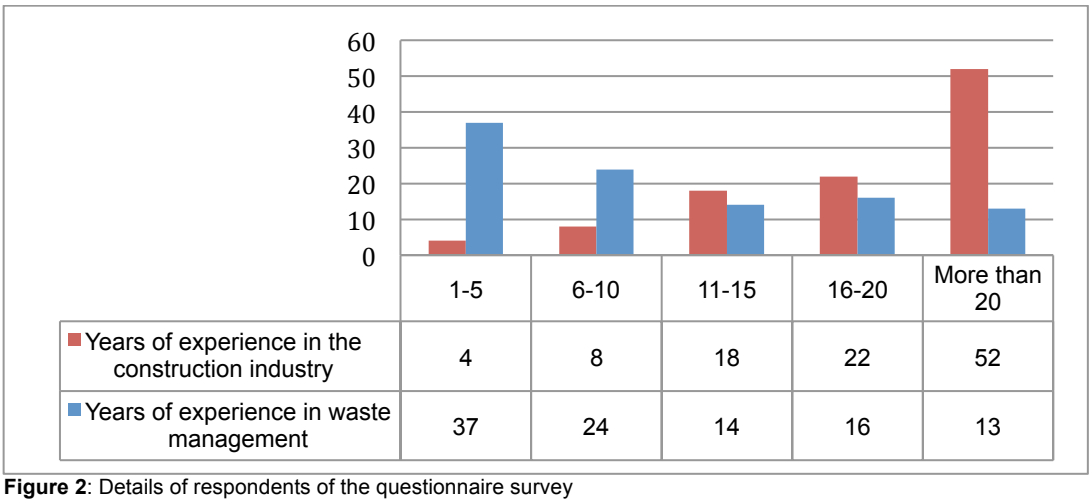
As argued by Braungart (2013) behaviour change emerges when as a society it is realised that current practices are no longer working properly. However, more recently behavior change approaches have been criticised by researchers like Crompton (2013) emphasising the necessity of a broader focus on environmental problems by implicitly acknowledging concepts related to structure and agency. For example, Hays (1994) argued that it is important to consider the way in which structural pressures place more or less constraint on the creative movements of people. Researchers have argued that individual behavioural change is motivated by context and social influences (Bandura 1989) including structural reforms such as laws, regulations (Ellen, Wiener, and Cobb-Walgren 1991) and media (Pelletier and Sharp 2008). However, researchers generally acknowledge that people's attitudes, values, beliefs (Murray 2013), individual decisions and motivations (Chapman, Skinner, and Searle 2013) influence their behaviour. Highlighting the theory of reasoned action, Bagozzi (1992) explained that behaviour is controlled by intention and intention is influenced by attitudes and subjective norms. According to the theory of planned behaviour, to perform a given behaviour, requires an intention to perform, as intentions capture the motivational factors which influence the behaviour (Ajzen 1991). However, habits, social context and social structure cannot be disregarded as these directly influence individual preferences (Chapman, Skinner, and Searle 2013).

Similarly, beliefs, values and behaviours that pass through generations are not changeable overnight as they have been stabilised by years of shared experiences and practices (Braungart 2013). Murray (2013) asserted that other than internal factors such as attitudes, values and beliefs, there are 'external'[1] factors including peer pressure, social norms and laws which also influence behaviours. He highlighted the importance of increasing positive values, attitudes and beliefs in order to change unwanted behaviours over the long term and transform them into positive ones. Similarly, performance of behaviours also depends on non-motivational factors such as time, cost, skills, and cooperation of others which can be broadly categorised under essential opportunities and resources to perform behaviours (Ajzen 1991). Intentions, perceptions of behavioural control, attitudes toward the behaviour, and social pressures to perform or not to perform the behaviour (subjective norms) can also help to change behaviours (Ajzen 1991). Therefore it is necessary to explore PMs' views on WM performance in construction projects; PMs' attitudes towards WM; and PMs' views on WM culture in construction projects to enhance the performance of construction WM practices in Australia.

[1] The internalisation of such 'external' societal forces is explored through Bourdieu's concept of 'habitus'

Research methodology

The findings presented in this paper are a part of a larger study which employed mixed methods. Mixed methods were employed in the main study to enable a clearer understanding of phenomenon than can be achieved using a single method (Bryman 2008). However, only the findings of quantitative methods are presented in this paper. A questionnaire survey was conducted to gather data related to PMs' views on WM performance in construction projects; PMs' attitudes towards WM; and PMs' views on WM culture in construction projects. As PMs have a vital involvement in WM in construction projects, PMs were selected as the target group to distribute questionnaires. As highlighted by Alreck and Settle (2004), sampling is necessary in questionnaire surveys due to the unrealistic involvement of enormous amounts of time, cost and personnel required to survey every individual in a population. The sample was selected from PMs who are registered in the Australian Institute of Project Management (AIPM), the Australian Institute of Building (AIB) and LinkedIn business networking website. The online survey tool 'Survey Monkey' was used to indicate the level of agreement or disagreement of respondents on WM performance in construction projects; attitudes towards WM; and views on WM culture in construction projects by using a five-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). 140 responses were received and out of these only 104 were used in the final analysis due to incomplete questionnaires. Figure 2 represents the details of respondents of the questionnaire survey.



	1-5	6-10	11-15	16-20	More than 20
Years of experience in the construction industry	4	8	18	22	52
Years of experience in waste management	37	24	14	16	13

Figure 2: Details of respondents of the questionnaire survey

It was noted that 88% of respondents had more than ten years of professional experience in the construction industry. 64% of respondents had more than five years of professional experience in the in the field of WM, which makes them well-qualified to answer the questionnaire. Of the respondents, 8% were working in client organisations, 63% were working under main contractors, 23% were working in consultant organisations and the remaining 6% were working in subcontractor organisations (see Figure 3).

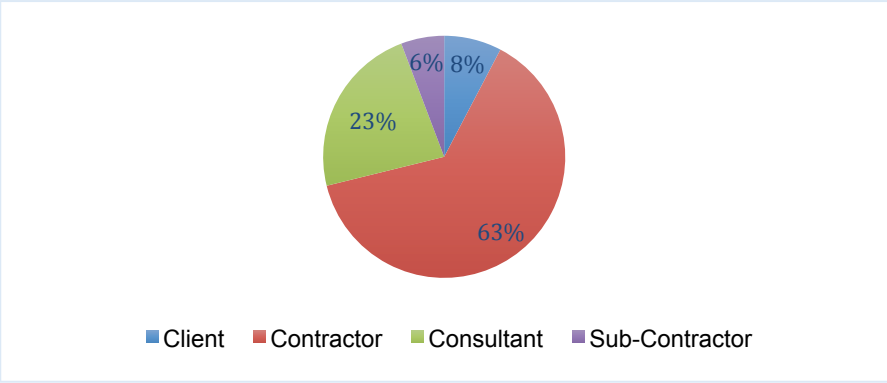


Figure 3: Type of organisation of respondents

The data was analysed using the IBM SPSS Statistics 22 software. Descriptive statistics were used to analyse the data. The Kruskal-Wallis test was used to examine whether there were significant differences between the PMs' attitudes towards WM; PMs' views on WM performance in construction projects; and PMs' views on WM culture in construction projects according to their organisation type as shown in Figure 3. As sample sizes were different in each category, Kruskal–Wallis one-way analysis of variance was carried out twice with overall sample and randomly selected equal samples.

Research findings

WM performance in construction projects

PMs' views on WM performance in construction projects were analysed using the following statements (see Table 1).

Table 1: Descriptive statistics and results of Kruskal–Wallis one-way analysis of variance of WM performance in construction projects

	WM performance in construction projects	Mean	Std. Deviation	Chi-Square with original sample	Asymp. Sig. with original sample	Chi-Square with equal sample sizes	Asymp. Sig. with equal sample sizes
WMP 1	Waste management systems comply with existing regulations	3.52	.776	15.741	.001	11.179	.011
WMP 2	The operational cost of waste minimisation is high in construction projects	3.34	1.103	2.269	.518	.977	.807
WMP 3	Construction project participants are in favour of recycling	3.33	.818	2.229	.526	2.840	.417
WMP 4	Most project participants are satisfied with existing WM systems	3.24	.865	.112	.990	.338	.953
WMP 5	Construction practitioners aware of waste management systems and collection services in construction	3.19	.915	1.128	.770	7.689	.053
WMP 6	Overall WM is profitable	3.13	1.025	6.362	.095	3.782	.286
WMP 7	Most recyclable waste is recovered from construction projects	3.02	1.088	2.397	.494	2.066	.559

WMP 8	Most construction project participants are eager to participate in waste management	2.97	1.000	5.614	.132	5.983	.112
WMP 9	Most construction waste is recovered compared to the total generated	2.88	1.091	7.512	.057	6.155	.104
WMP 10	Waste separation is sufficient in most of the construction projects	2.82	1.022	4.138	.247	1.655	.647
WMP 11	WM systems cover the life cycle of building	2.75	.900	2.526	.471	.487	.922
WMP 12	Overall waste management efforts are at a satisfactory level in construction projects	2.62	.958	6.078	.108	3.448	.328

As shown in the Table 1, at the construction project level, PMs believe that WM systems comply with existing regulations and construction project participants are aware of WM systems and collection services in construction. PMs believe that construction project participants are in favour of recycling and most recyclable waste is recovered from construction projects. However, at the overall level, PMs agreed that most construction waste is not recovered compared to the total generated and the operational cost of waste minimisation is high in construction projects despite the fact that overall WM is profitable. Even though most project participants are satisfied with existing WM systems, waste separation is not sufficient in most construction projects and construction practitioners are not eager to participate in WM. Thus, PMs accept that WM systems do not cover the building life cycle and overall WM efforts are not at a satisfactory level in construction projects.

As shown in Table 1 except WMP 1, all other significance values of Kruskal–Wallis one-way analysis of variance test are greater than 0.05. Therefore it can be concluded that statistically there is no significant difference in PMs' views on WM performance in construction projects according to their organisation type except the first factor. As there are differences among views on WMP 1 among PMs from different organisational categories, post-hoc testing was carried out to find out which groups have different views. Pair-wise multiple comparisons were carried out among organisational groups to identify which group is different from other groups.

Table 2: Results of post-hoc testing among PM groups on WM systems comply with existing regulations

		Client	Consultant	Contractor
Consultant	Chi-Square	.167		
	Asymp. Sig.	.683		
Contractor	Chi-Square	4.438	8.315	
	Asymp. Sig.	**.035**	**.004**	
Sub-contractor	Chi-Square	.672	2.020	7.950
	Asymp. Sig.	.412	.155	**.005**

As shown in Table 2 PMs who are working under contracting organisations have different views from other PMs. This could be due to differences in their professional roles in construction projects.

PMs' attitudes towards WM

The descriptive statistics and results of Kruskal–Wallis one-way analysis of variance related to PMs' attitudes towards WM are shown in Table 3.

Table 3: Descriptive statistics and results of Kruskal–Wallis one-way analysis of variance of PMs' attitudes towards WM

	PMs' attitudes towards WM	Mean	Std. Deviation	Chi-Square with original sample	Asymp. Sig. with original sample	Chi-Square with equal sample sizes	Asymp. Sig. with equal sample sizes
A 1	Implementing WM plans in construction projects is cost effective	3.80	.999	4.956	.175	4.092	.252
A 2	Contractors are responsible for waste minimisation	3.72	1.000	1.202	.753	1.919	.589
A 3	People involved in the construction process are willing to use recycled materials in construction projects	3.62	.840	2.684	.443	2.642	.450
A 4	Waste is an inevitable by-product	3.60	1.102	3.999	.262	1.215	.749
A 5	Adoption of environmentally friendly measures towards WM (such as reduce, reuse and recycle) depends on their profitability	2.99	1.019	.196	.978	1.045	.790
A 6	WM is less important than profit maximization	2.61	.999	3.031	.387	5.262	.154
A 7	Time spent on WM is a loss of production time	2.17	.960	.600	.896	1.838	.607
A 8	WM is beyond the control of project members	1.79	.759	2.588	.460	1.080	.782
A 9	Waste has no value	1.76	.631	.837	.841	1.438	.697

It can be clearly seen from Table 3 that PMs believe adoption of environmentally friendly measures towards WM (such as reduce, reuse and recycle) does not depend on their profitability and that implementing WM plans in construction projects is cost effective. PMs also agreed that people involved in the construction process are willing to use recycled materials in construction projects. However they still believe that contractors are responsible for waste minimisation and waste is an inevitable by-product. It is interesting to see that according to this analysis PMs do not believe that WM is less important than profit maximization; time spent on WM is a loss of production time; WM is beyond the control of project members; and waste has no value. According to the results of Kruskal–Wallis one-way analysis of variance of PMs' attitudes towards WM, all of the significance values are greater than 0.05 (see Table 3). Therefore it can be concluded that statistically there is no significant difference in PMs' attitudes towards WM according to their organisation type.

WM culture in construction projects

The descriptive statistics and the results of Kruskal–Wallis one-way analysis of variance related to WM culture in construction projects are shown in Table 4.

Table 4: Descriptive statistics and results of Kruskal–Wallis one-way analysis of variance of WM culture in construction projects

	WM culture in construction projects	Mean	Std. Deviation	Chi-Square with original sample	Asymp. Sig. with original sample	Chi-Square with equal sample sizes	Asymp. Sig. with equal sample sizes
WMC 1	Project participants are cost and time conscious in WM	3.28	1.009	.685	.877	.787	.852
WMC 2	Project participants follow many rules and standard procedures in WM	3.19	.904	1.753	.625	.875	.831
WMC 3	Progress is tracked against stated goals in WM	3.14	.980	3.024	.388	2.601	.457
WMC 4	New participants are easily integrated into the WM system	3.04	.858	1.449	.694	.759	.859
WMC 5	Each party has the option to express their interest in WM	3.02	1.061	3.488	.322	3.504	.320
WMC 6	Project participants are willing to express their doubts and feel comfortable in providing early warning of potential problems in WM	2.99	.960	.299	.960	2.070	.558
WMC 7	Roles, responsibilities and duties of each party in WM are well-coordinated and fully understood	2.82	1.059	.762	.859	1.515	.679
WMC 8	Project participants share a high degree of commitment to successful implementation of WM plans	2.81	.904	.897	.826	4.308	.230
WMC 9	Project participants are consistently open, honest and respectful with each other viewpoints in WM	2.79	.921	4.135	.247	5.324	.150
WMC 10	All project participants have a clear understanding of the objectives and values in WM	2.69	.925	1.214	.750	2.883	.410

As shown in the Table 4, when it comes to WM culture in construction projects, PMs believe that project participants are cost and time conscious in WM; follow many rules and standard procedures in WM; progress is tracked against stated goals in WM; and new participants are easily integrated into the WM system. However they presume that even though each party has the option to express their interest in WM, project participants are not willing to express their doubts and not feel comfortable in providing early warning of potential problems in WM. Furthermore PMs do not believe that roles, responsibilities and duties of each party in WM are well-coordinated and fully understood in construction projects; project participants share a high degree of commitment in successful implementation of WM plans; project participants are consistently open, honest and respectful with each other viewpoints in WM; and all project participants have a clear understanding of the objectives and values in WM. The results of Kruskal–Wallis one-way analysis of variance of PMs' views on WM culture in construction projects are shown in Table 4. As shown in Table 4, as all significance values are greater than 0.05, it can be concluded that statistically there is no significant

difference in PMs' views on WM culture in construction projects according to their organisation type.

Discussion

According to the findings of this research, PMs believe that construction practitioners are adequately aware of WM systems and collection services in construction and that WM systems are compliant with existing regulations. However, it was found that even though most project participants are satisfied with existing WM systems, PMs believe that overall WM efforts are not at a satisfactory level in construction projects. Thus, it is necessary to identify appropriate measures to increase the efforts of construction project participants to improve the performance of WM. Most construction waste is not recovered compared to the total generated in construction projects and waste separation is not sufficient in most construction projects. As assessed by PMs, WM systems do not cover the building life cycle and most construction project participants are not eager to participate in WM. Therefore, it is necessary to encourage construction practitioners to consider the whole life of building when implementing WM practices and to find ways to motivate construction practitioners to participate in WM actions while improving waste sorting facilities in construction projects. When considering the cost of WM, PMs believe that the operational cost of waste minimisation is high in construction projects even though implementing WM plans in construction projects is cost effective and profitable. Also, PMs believed that construction project participants are cost and time conscious in WM, which is characteristic of the construction context as supported by Wong and Yip (2004), and Yuan and Shen (2011). However, PMs do not believe that WM is less important than profit maximization; time spent on WM is a loss of production time; WM is beyond the control of project members; and waste has no value. These findings reflect the struggle between structure and agency, where the pressures of time and cost conditioning the construction industry, along with broader cultural constructions of 'waste' and 'value' may be restraining the implementation of WM practices despite individual beliefs. Despite individual project mangers' acknowledgement of the importance of WM, they consider waste as an inevitable by-product. At the same time it can be argued that the cooperative and collaborative nature of WM has not been properly acknowledged in the Australian construction context as PMs still believe contractors are responsible for waste minimisation. PMs do not believe that all project participants have a clear understanding of the objectives and values in WM; roles, responsibilities and duties of each party in WM are well-coordinated and fully understood in construction projects; project participants share a high degree of commitment in successful implementation of WM plans; and project participants are consistently open, honest and respectful with each other viewpoints in WM. Thus, it is necessary to take necessary actions to enhance WM culture in construction projects. According to research findings, even though each party has the option to express their interest in WM, project participants do not seem willing to express their doubts and do not feel comfortable in providing early warning of potential problems relating to WM. Thus, it is necessary to find ways to encourage, develop and promote already existing cooperative and collaborative structures in construction projects in order to address the deficiencies of the current broader structural environment that rewards and prioritises individualisation and competition.

Conclusions

By acknowledging the cultural construction of waste, the findings of this research reveal the lack of holistic understandings of waste when implementing WM practices in construction projects. Thus, it is necessary to find mechanisms to encourage construction project participants to consider the whole life of buildings and embrace more holistic understandings of 'waste' and 'value' in relation to WM practices. Collaboration and cooperation in WM is required to avoid all WM responsibility being placed on the builder while encouraging construction practitioners to provide early warning of potential problems in WM where necessary in construction projects. Research findings clearly indicate the importance of proper communication of objectives and values in WM and the roles, responsibilities and duties of each party in WM; as this is not currently properly practiced in construction projects. Also it is necessary to address issues with commitment to implementation of WM actions by enabling consistently open, honest and respectful dialogue between the different parties involved in WM. It is also essential to find ways to motivate construction practitioners to participate in WM actions while improving waste sorting facilities in construction projects and facilitating appropriate structural conditions in the construction industry. However, the rules and values of the construction context are also influenced by wider structural conditions, including broader political and economic values and the short-term focus of current political and financial cycles. Findings suggest it is necessary for the construction industry to find ways to reduce the operational cost of WM as it was identified by construction project participants that waste is valuable even though they believe that it is an inevitable byproduct of construction projects. Thus, the findings of this study could be useful for decision makers in formulating strategies to improve current construction WM practices in Australia by addressing cultural and human factors. Furthermore, the research has demonstrated how individual actions in WM are constrained by structural conditions including the way in which waste, value and productivity are conceptualised within the industry due to broader pressures on time and limited conceptualisations of cost. Further research could focus on identifying ways to address the above mentioned issues in order to improve WM performance in construction projects in Australia.

References

Ajzen, Icek. 1991. "The theory of planned behavior." *Organizational Behavior and Human Decision Processes* 50 (2):179-211.

Alreck, Pamela L, and Robert B Settle. 2004. *The survey research handbook*. 3rd ed, *McGraw-Hill/Irwin series in marketing*. Boston: McGraw-Hill/Irwin.

Anderson, E. S. 2003. "Understanding your project organization's character." *Project Management Journal* 34 (4):4-11.

Australian Bureau of Statistics. 2011. "8698.0 - Waste Management Services, Australia, 2009-10." Australian Government, Last Modified 14/06/2011 Accessed 26/02/2013. http://www.abs.gov.au/ausstats/abs@.nsf/Products/8698.0~2009-10~Main+Features~Waste+management+services.

Australian Bureau of Statistics. 2013. "4602.0.55.005 - Waste Account, Australia, Experimental Estimates, 2013." Australian Government, Last Modified 19/02/2013 Accessed 11/12/2014. http://www.abs.gov.au/ausstats/abs@.nsf/Products/4602.0.55.005~2013~Main+Features~Main+Findings?OpenDocument.

Australian Government. 2013. National Waste Reporting. edited by Department of Environment. Canberra: Department of Environment.

Bagozzi, Richard P. 1992. "The self-regulation of attitudes, intentions, and behavior." *Social Psychology Quarterly* 55 (2):178-204.

Bandura, Albert. 1989. "Human agency in social cognitive theory." *American psychologist* 44 (9):1175.

Begum, R.A., C. Siwar, J.J. Pereira, and A.H. Jaafar. 2009. "Attitude and behavioral factors in waste management in the construction industry of Malaysia." *Resources, Conservation and Recycling* 53 (6):321-328. doi: 10.1016/j.resconrec.2009.01.005.

Bossink, B. A. G., and H. J. H. Brouwers. 1996. "Construction waste: quantification and source evaluation." *Journal of Construction Engineering and Management* 122 (1):55-60.

Braungart, Michael. 2013. "Foreward." In *Motivating change : sustainable design and behaviour in the built environment*, edited by Robert Crocker and Steffen Lehmann, xxii-xxiii. Abingdon, Oxon: Routledge.

Brewer, Graham, and Thayaparan Gajendran. 2010. "A case study of the effects of attitude, behaviour, and project team culture on building information model use in a temporary project organisation." CIB W78 2010: 27th International Conference, Applications of IT in the AEC Industry, Cairo, Egypt, 16-19 November, 2010.

Bryman, Alan. 2008. *Social research methods*. 3rd ed. Oxford: Oxford University Press.

Burke, Rory. 2007. *Project management techniques*. 0th ed. [United States]: Burke Publishing.

Chapman, Janine, Natalie Skinner, and Sharni Searle. 2013. "Working towards sustainability: exploring the workplace as a site for pro-environmental behavioural change." In *Motivating change : sustainable design and behaviour in the built environment*, edited by Robert Crocker and Steffen Lehmann, 56-70. Abingdon, Oxon: Routledge.

Coventry, Stuart, and Peter Guthrie. 1998. *Waste minimisation and recycling in construction: design manual*. Vol. 134. London: CIRIA.

Crompton, Tom. 2013. "Behaviour change: a dangerous distraction." In *Motivating change : sustainable design and behaviour in the built environment*, edited by Robert Crocker and Steffen Lehmann, 111-126. Abingdon, Oxon: Routledge.

Dainty, Andrew, Stuart Green, and Barbara Bagilhole. 2007. "People and culture in construction: a reader." In *People and Culture in Construction* edited by Andrew Dainty, Stuart Green and Barbara Bagilhole, 3-25. New York: Routledge.

Dajadian, Shant A., and Daphene C. Koch. 2014. "Waste management models and their applications on construction sites." *International Journal of Construction Engineering and Management* 3 (3):91-98.

Ellen, Pam Scholder, Joshua Lyle Wiener, and Cathy Cobb-Walgren. 1991. "The role of perceived consumer effectiveness in motivating environmentally conscious behaviors." *Journal of Public Policy & Marketing*:102-117.

Graham, P. , and G. Smithers. 1996. "Construction waste minimisation for Australian residential development." *Asia Pacific Journal of Building and Construction Management* 2 (1):14-19.

Gray, Roderic J. 2001. "Organisational climate and project success." *International Journal of Project Management* 19 (2):103-109. doi: 10.1016/s0263-7863(99)00060-5.

Hardie, M., S. Khan, A. O'Donnell, and G. Miller. 2007. "The efficacy of waste management plans in Australian commercial construction refurbishment projects." *Australian Journal of Construction Economics and Building* 7:26-36.

Hays, Sharon. 1994. "Structure and agency and the sticky problem of culture." *Sociological Theory* 12:57-57.

Jaillon, L., CS Poon, and YH Chiang. 2009. "Quantifying the waste reduction potential of using prefabrication in building construction in Hong Kong." *Waste Management* 29 (1):309-320.

Johnston, Hal, and William R. Mincks. 1995. "Cost-effective waste minimization for construction managers." *Cost Engineering* 37 (1):31-40.

Lingard, H., P. Graham, and G. Smithers. 1997. "Waste management in the Australian construction industry: a human factors approach." 13th Annual ARCOM Conference, King's College, Cambridge, 15-17 September 1997.

Lingard, H., P. Graham, and G. Smithers. 2000. "Employee perceptions of the solid waste management system operating in a large Australian contracting organization: implications for company policy implementation." *Construction Management and Economics* 18 (4):383-393. doi: 10.1080/01446190050024806.

Manowong, Ektewan. 2012. "Investigating factors influencing construction waste management efforts in developing countries: an experience from Thailand." *Waste Management and Research* 30 (1):56-71.

McDonough, William, and Michael Braungart. 2003. "Towards a sustaining architecture for the 21st century: the promise of cradle-to-cradle design." *Industry and Environment* 26 (2):13-16.

McDonough, William, and Michael Braungart. 2009. *Cradle to cradle : remaking the way we make things*. Edited by Michael Braungart. 2008 ed. ed. London :: Vintage.

Moser, Walter. 2007. Garbage and Recycling: From Literary Theme to Mode of Production. *Other Voices* 3 (1). Accessed 11/12/2014.

Murray, Paul. 2013. "Leading by design." In *Cultivating self-leadership for sustainability*, edited by Robert Crocker and Steffen Lehmann, xxiv-xxxi. Abingdon, Oxon: Routledge.

Ochieng, E. G., and A. D. F. Price. 2010. "Managing cross-cultural communication in multicultural construction project teams: The case of Kenya and UK." *International Journal of Project Management* 28 (5):449-460. doi: 10.1016/j.ijproman.2009.08.001.

Osmani, M., J. Glass, and A.D.F. Price. 2008. "Architects' perspectives on construction waste reduction by design." *Waste Management* 28 (7):1147-1158.

Pelletier, Luc G, and Elizabeth Sharp. 2008. "Persuasive communication and proenvironmental behaviours: How message tailoring and message framing can improve the integration of behaviours through self-determined motivation." *Canadian Psychology/Psychologie canadienne* 49 (3):210.

Pongrácz, Eva, and Veikko J Pohjola. 2004. "Re-defining waste, the concept of ownership and the role of waste management." *Resources, Conservation and Recycling* 40 (2):141-153.

Riley, M. J., and D. Clare-Brown. 2001. "Comparison of cultures in construction and manufacturing industries." *Journal of Management in Engineering* 17 (3):149-158.

Shen, L. Y., V. W. Y. Tam, C. M. Tam, and D. Drew. 2004. "Mapping approach for examining waste management on construction sites." *Journal of Construction Engineering and Management* 130 (4):472-481.

Sousa-Poza, Andres, and Morgan Henrie. 2005. "Project management: a cultural literary review." *Project Management Journal* 36 (2):5-14.

Thomas, R., M. Marosszeky, K. Karim, S. Davis, and D. McGeorge. 2002. "The importance of project culture in achieving quality outcomes in construction." Proceedings IGLC-10, Gramado, Brazil.

Wong, Evia O. W., and Robin C. P. Yip. 2004. "Promoting sustainable construction waste management in Hong Kong." *Construction Management and Economics* 22 (6):563-566. doi: 10.1080/0144619042000226270.

Yuan, H. , and L. Shen. 2011. "Trend of the research on construction and demolition waste management." *Waste Management* 31 (4):670-679.

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Barriers to Construction and Demolition Waste Management in Developing Countries: Case of Iran

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In light of the lack of interest in implementing waste management in developing countries such as Iran; exploring the barriers to waste management implementation becomes relevant as the driving force behind conducting the present study. Major barriers identified in previous studies, were selected through a review of literature. Afterwards, a questionnaire survey was administered among different categories of Iranian construction contractors and 101 duly completed questionnaires were received. Ranking of 15 barriers through statistical analysis revealed the absence of a systematic regulatory regime for Construction and Demolition (C&D) waste management for construction projects. Among other findings, a lack of attention to waste management in regulations; lack of necessary skills and knowledge among construction practitioners; lack of economically viable methods for managing waste; and lack of attention to waste management within the dominant culture of the community were identified as the most five important barriers to C&D waste management in Iran. This was perceived by Iranian contractors giving a clear message that the scant attention paid to C&D waste management by policy makers has resulted in a lack of cooperation from involved parties and stakeholders on construction projects. The present study contributes to the field by highlighting the barriers to waste management implementation in a developing country and offering remedial solutions to identified barriers. The findings establish the field by providing a basis for future investigations and offers assistance in promoting C&D waste management in developing countries.

Keywords: construction and demolition, waste management, construction projects, barriers, developing country, Iran

Introduction

Developing countries encounter grave problems in terms of pollution and devastation of its built environment. Nevertheless, most of developing countries have adopted the same approach in regards to their built environments namely placing economic development above environmental concerns (Chini and Nasri 2009, Ghazinoory 2005). In view of the urgent priority assigned to improvement of infrastructure and the large budget allocated to construction activities (Ghoddousi and Hosseini 2012), developing nations are confronting serious issues in terms of the C&D waste generated in construction activities. As the first step to resolving the abovementioned issues in developing countries, the barriers impeding effective implementation of C&D waste management should be identified accurately (Poon 2007). Nevertheless, developing countries are still lagging behind in identifying such barriers as postulated by Yuan and Shen (2011) and still struggle to establish an effective environmentally-friendly system for dealing with C&D waste. As an example, TWMO (2014) state that, the amount of annually C&D waste generated in Iran's capital city (Tehran) amounted to around 23 million tons during the period 2013-2014. Only a small fraction from this was recycled and the rest was disposed in landfills. This points to the conspicuous absence of an effective C&D waste management regime in the country, which leads to squandering available resources as asserted by Saghafi and Teshnizi (2011). Besides, such large amounts of solid waste pose a wide range of environmental predicaments for Iran in as much as C&D waste pollutants are not identified and properly treated before disposal in landfills (Ghazinoory, 2005).

Against this backdrop, review of the literature reveals a lack of research in developing countries on identifying the barriers and proposing solution for improving the current state of C&D waste management. By unearthing the common barriers in developing countries and as the first study in its kind within the Iranian construction industry; the following is an attempt made to ascertain the major barriers to implementation of an effective C&D waste management regime in the construction industry in developing countries such as Iran.

Review of literature

All the waste generated as the result of construction, renovation and demolition activities is called C&D waste. C&D waste is usually generated during excavation, building construction, cleaning the sites, demolition activities, road jobs and renovation of building (Shen et al. 2004, Wu et al. 2014). As posited by Kartam et al. (2004) C&D waste represent a major part of municipal solid waste (i.e. around 15–30% of total solid waste by weight). The construction industry has a poor reputation for consuming huge amounts of natural resources and generating an enormous mass of C&D waste (Poon 2007). Nevertheless, studies from various countries have revealed a lack of interest for implementing C&D waste management effectively due to a wide range of reasons (Yuan and Shen 2011). As an example, recent study by Poon et al. (2013) in Hong Kong discovered that contractors still treat waste management as a cost centre, which adversely affects the competitiveness of contractors. For the sake of brevity, the main barriers to C&D waste management as identified in previous studies are illustrated in Table 1.

Table 1: Main barriers to C & D waste management

Rows	Barriers	Previous studies
1	Lack of awareness among contractors about waste management	Poon (2007) Yean Yng Ling and Song Anh Nguyen (2013)
2	Lack of regulations and building codes to mandate waste management in the construction industry	Ekanayake and Ofori (2004) (Yean Yng Ling and Song Anh Nguyen 2013)
3	Lack of support from building supervisors, designers, owners and key stakeholders	(Yean Yng Ling and Song Anh Nguyen 2013)
6	Lack of incentives from regulatory authorities in the construction industry	(Yean Yng Ling and Song Anh Nguyen 2013)
7	Low costs of sending materials to landfill	(Poon 2007) (Yean Yng Ling and Song Anh Nguyen 2013) (Najafpoor and Jamali-Behnam 2014)
9	Lack of a culture in favour of waste management among construction practitioners	(Teo and Loosemore 2001) (Yean Yng Ling and Song Anh Nguyen 2013)
10	Lack of attention to waste management from the community	(Teo and Loosemore 2001)
11	Lack of economically-viable facilities for waste management	(Sassi 2008)
13	Low prices of building materials (waste management is not economically justified)	(Poon 2007)
14	Lack of budget for managing waste	(Yean Yng Ling and Song Anh Nguyen 2013)
15	Tight scheduling of construction projects	(Yean Yng Ling and Song Anh Nguyen 2013)

Research methods

The questionnaire for the study was divided into three main sections comprising (1) demographics of respondent, (2) three questions for evaluation of the current state of waste management on construction projects. (3) Representing 15 items identified from the literature to elucidate the perceptions of respondents. This is regarding the level of influence of each item in impeding implementation of an effective waste management regime in the country. The questionnaire was designed based on a five-point Likert rating scale comprising very high effect=5, high effect=4, moderate effect=3, low effect=2, and very low effect=1. The developed questionnaire was pilot tested by sending it to three project managers. Feedback obtained was incorporated into the questionnaire prior to delivering the survey to the population of interest.

The target population included contractors active in all types of construction activities in Tehran. According to the formal classification of contractors currently in place in Iran, construction companies active in government projects are classified into 5 categories. Those in class 1 are the most large-sized and are allowed to undertake projects with the biggest budgets (Ghoddousi and Hosseini 2012) while companies in class 5 are usually newly-established companies that carry out small projects. Apart from these 5 categories, some companies are active in housing developments in the private sector. The target population covered both private sector companies and those clarified in 5 classes as described above. Invitations were sent out to 350 companies in October 2014. 125 responses were received by February 2015. Inspection of retuned questionnaires resulted in considering 101 properly-completed questionnaires manifesting a response rate of around 28%.

Having a population of over 10 million (i.e. 1/7 of Iran's population), Tehran is Iran's largest city and among the most populated capitals in the world. Due to the concentration of a wide range of socio-economic opportunities, construction practitioners from all professional areas and from other regions of the country migrate to Tehran in search of work. Hence, Tehran was regarded as a representative of a pool of a wide range of construction practitioners from various backgrounds as argued by Ghoddousi et al. (2014).

Results and discussions

Respondents' profile

Table 2 illustrates the profile of respondents a reflection of the respondents in terms of the nature of activity. As such, around 50% of respondents were from private building companies while 50% came from licensed contractors active in government-funded projects. Additionally, nearly 78% of respondents had at least 6 years of experience in the construction sector. Thus, they were deemed adequately knowledgeable of the issues associated with waste management.

Table 2: Profile of respondents

Contractor Type*	Experience (years)				Total
	up to 5	6-10	11 - 20	more than 21	
Grade 1	3	3	8	2	16
Grade 2	1	3	5	4	13
Grade 3	1	2	3	2	8
Grade 4	1	1	2	0	4
Grade 5	0	4	2	2	8
Private Builder	16	16	17	3	52
Total	22	29	37	13	101

Notes:* According to the formal classification of contractors as currently in place in Iran, construction companies active in government projects are classified into 5 categories. Those in class 1 are allowed to undertake projects with the biggest budgets (Ghoddousi and Hosseini 2012).

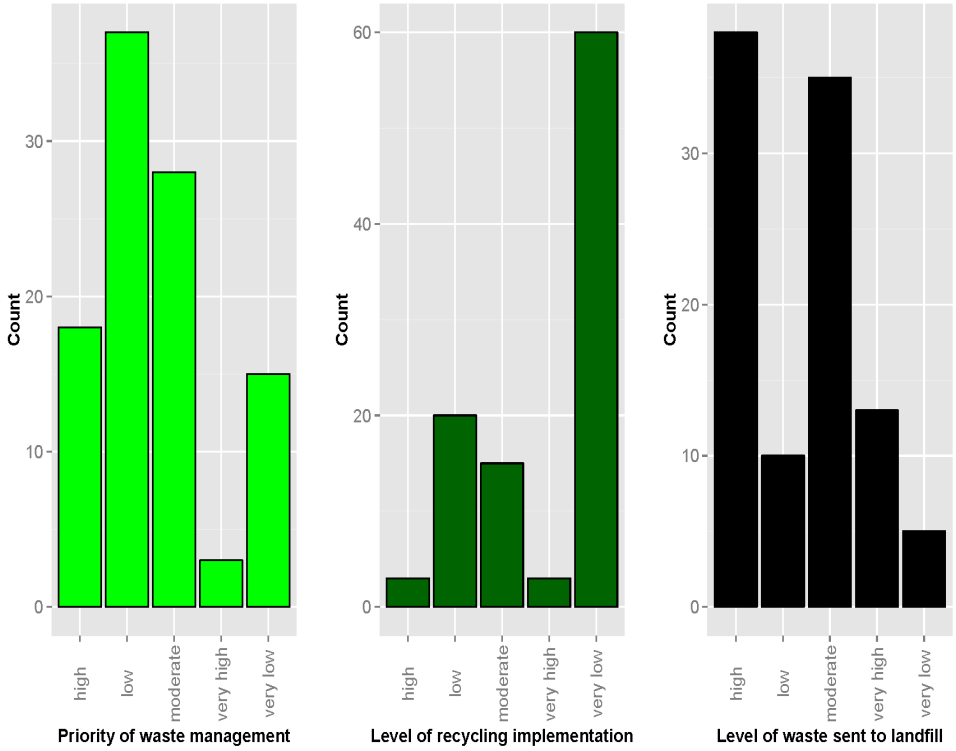

Figure 1: Current state of C&D waste management in Iran

Current state of waste management

To evaluate the current state of waste management in Iran, respondents were asked to indicate their perception regarding the level of priority assigned to waste management on their projects; the level of recycling implementation and the level of waste sent to landfill on a scale from very low to very high as illustrated in Figure 1.

Mostly entirely, respondents indicated that the priority assigned to C&D waste management is moderate or low as illustrated in Figure 1. This reaffirms the observations by Ghazinoory (2005) denoting the lack of attention to construction waste management in Iran. Around 80% of respondents (see Figure 1) described the level of recycling on construction projects as very low (60%) and low (20%), which acknowledged the arguments by Saghafi and Teshnizi (2011) regarding low level of recycling C&D waste in Iran. This was echoed judging from the level of waste sent to landfill as illustrated in Figure 1 that was described by around 80% of respondents as very high, high and moderate.

Main barriers to C&D waste implementation

The reliability analysis for the 15 items resulted in the Cronbach's Alpha coefficient value of 0.787. This exceeded the accepted norm of 0.7 according to Nunnally and Bernstein (1994), implying the acceptable reliability of the measurements instrument. These 15 items were ranked according to the Coefficient of Variation (CV) for each item illustrated in Table 3. CV defined according to equation 1 is reflective of the variability in the answers provided by the respondents, hence smaller CVs show higher levels of agreement on the item as indicated by the respondents (Sheskin 2007). As a result, CV has been an indication utilised for ranking items and variables based on perceptions of respondents in construction literature (Ghoddousi and Hosseini 2012). Table 3

illustrates the results of ranking 15 barriers to implementation of C&D waste management in Iran.

$$CV = (\text{Standard Deviation})/\text{Mean} \qquad \textbf{Equation 1}$$

Table 3: Ranking of barriers to implementing construction and demolition waste management in Iran

Barriers	Mean	Std. Deviation	CV	Rank
Lack of attention to waste management in current regulations	4.080	.79603	0.195	1
Lack of incentives from regulatory authorities	4.070	.81557	0.200	2
Lack of awareness among contractors about waste management	4.000	.87178	0.218	3
Lack of economically-viable facilities for waste management	4.149	.92072	0.222	4
Lack of waste management necessities within the national building codes	3.931	.87473	0.223	5
Lack of a culture in favour of waste management	3.980	.90532	0.227	6
Lack of attention to waste management from the community	4.000	.92736	0.232	7
Lack of support from owners and stakeholders	3.812	.91338	0.240	8
Lack of support from building supervisors	3.871	.95565	0.247	9
Lack of regulations to make waste management an obligation	3.822	1.05258	0.275	10
Lack of attention to designing buildings according to requirements of waste management	3.733	1.03818	0.278	11
Lack of budget for managing waste	3.356	1.10076	0.328	12
Low costs of sending materials to landfill	3.416	1.12488	0.329	13
Low prices of building materials (waste management is not economically justified)	3.297	1.12734	0.342	14
Tight scheduling of construction projects	3.149	1.08983	0.346	15

According to Bai and Sarkis (2013) organisations comply with government regulations to improve their environmental performance. Thus, in absence of such regulations,

organisations will not make a determined attempt to improve their performance in terms of environmental concerns including managing their waste. This was the case observed in Iran as reflected in Table 3. That is, the first barrier as perceived by the respondents reflected the lack of regulations in Iran to mandate management of waste. As the second most effective barrier, respondents referred to lack of incentives for C&D waste management in Iran. This was in line with the observations made by Yuan and Shen (2011) according to which incentives from the government could play a vital role in promoting C&D waste management within the construction industry.

A crucial element for effective implementation of C&D waste management is creating knowledge on its major aspects. An overlooked area in many developing countries as asserted by Yuan and Shen (2011). In the same vein, the third barriers to C&D waste management was identified as lack of awareness within the industry in Iran. This calls for further research to enhance the level of knowledge and awareness in the country regarding major features of managing C&D waste management within the Iranian context. Lack of an appropriate economically viable solution was observed as the 4th main barrier to management of C&D in Iran similar to the case of Hong Kong (Poon et al. 2013). According to which most of contractors mentioned a lack of suitable and commercial options for managing waste as a serious barrier for managing generated waste on construction projects.

The 5th and 10th most important barriers to C&D waste management were identified as the lack of waste management necessities within the national building codes and relevant regulations. This brings to light the dire need of revising the regulatory regime organising construction projects in Iran in order to augment them with the necessary legal enforcements in regards to C&D waste management. That is, when C&D waste management has no business-oriented justification, construction practitioners will not consider it as a necessary element on their projects. This explains why the respondents regarded lack of attention from the main stakeholders, owners, supervisors and designers involved in construction projects as the 8th, 9th, and 11th barriers to C&D waste management in Iran. As evidence of widespread negative effects of lack of mandatory regulations for construction activities, C&D waste management implementation became mandatory within the Portuguese construction industry (De Melo, Goncalves, and Martins, 2011).

It is inferred from Table 3 that lack of budget, tight scheduling and low costs of sending materials to landfills are not serious barriers for implementing C&D waste management in Iran. These were ranked as the 12th-15th factors namely the least effective ones in impeding C&D waste management In Iran.

Conclusions

It could be inferred from the findings that barriers associated with the project environment namely lack of regulatory obligations have the most impeding effects in hindering effectual implementation of C&D waste management in developing countries. On the other hand, barriers associated with projects (cost, time, and low expenses of disposal) were regarded as low influential. As such, lack of regulations and absence of government-backed policies in favour of C&D waste management are practically the main causes preventing establishing an effective system of C&D waste management in developing countries. Implication is that waste generators (construction practitioners in different roles) should put in extra effort for waste management, which in some cases incurs cost. Therefore, according to Yuan and Shen (2011, 678) "… the sole way to regulate their disposal behaviours is the governmental regulation.". This highlights the

crucial role of paying attention to enforcing C&D waste management in developing countries. Otherwise, having an effective system for preventing generation and disposal of large amounts of waste will not materialize within the context of developing countries such as Iran.

The study provides an illuminating insight into the status and the nature of barriers to C&D waste management in developing countries. Yet, direct applicability of the findings to all developing countries should be considered with caution due to the limitations in conducting the present study. This mainly refers to having Iran as the only case for collecting data. Thus, further research is warranted to replicate this study in other developing countries in order to add validity to the findings as outlined in the present study. In the meantime, policy makers should embark on identifying suitable and viable waste management regulations that enforce management of C&D waste in tandem with stimulating interests of different project practitioners. This points to another lucrative area for research namely investigating the economically-viable regulations in favor of C&D waste management applicable to the socio-economic characteristics of developing countries

References

Bai, Chunguang, and Joseph Sarkis. 2013. "Flexibility in reverse logistics: a framework and evaluation approach." *Journal of Cleaner Production* 47:306-318. doi: http://dx.doi.org/10.1016/j.jclepro.2013.01.005.

Chini, Abdol R, and Ehsan Nasri. 2009. "Sustainable Development, Engineering Education and Iranian Academe: Strategies and Related Issues." *Bimonthly Journal of Faculty of Engineering (University of Tehran)* 43 (Special issue on Conferenece on Engineering Education in 2025):191- 198 (available at: http://jfe.ut.ac.ir/pdf_20378_1ee51e3eb31fea35d086fb9f482ce3f4.html).

De Melo, Aluísio Braz, Arlindo F Goncalves, and Isabel M Martins. 2011. "Construction and demolition waste generation and management in Lisbon (Portugal)." *Resources, Conservation and Recycling* 55 (12):1252-1264.

Ekanayake, Lawrence Lesly, and George Ofori. 2004. "Building waste assessment score: design-based tool." *Building and Environment* 39 (7):851-861.

Ghazinoory, S. 2005. "Cleaner production in Iran: necessities and priorities." *Journal of Cleaner Production* 13 (8):755-762.

Ghoddousi, Parviz, Nima Bahrami, Nicholas Chileshe, and M. Reza Hosseini. 2014. "Mapping site-based construction workers' motivation: Expectancy theory approach." *Australasian Journal of Construction Economics and Buildingn* 14 (1):60-77.

Ghoddousi, Parviz, and M. Reza Hosseini. 2012. "A survey of the factors affecting the productivity of construction projects in Iran." *Technological and Economic Development of Economy* 18 (1):99-116.

Kartam, Nabil, Nayef Al-Mutairi, Ibrahim Al-Ghusain, and Jasem Al-Humoud. 2004. "Environmental management of construction and demolition waste in Kuwait." *Waste Management* , 24(10):1049-1059. doi: http://dx.doi.org/10.1016/j.wasman.2004.06.003.

Najafpoor, Ali Asghar, and Farideh Jamali-Behnam. 2014. "A Study Identifying Causes of Construction Waste Production and Applying Safety Management on Construction Site." *Iranian Journal of Health Sciences* 2 (3):49-54.

Nunnally, Jum C., and Ira H. Bernstein. 1994. *Psychometric theory*. New York: McGraw-Hill.

Poon, CS. 2007. "Management of construction and demolition waste." *Waste Management* 27 (2):159-160. doi: http://dx.doi.org/10.1016/j.wasman.2006.10.012.

Poon, CS, Ann TW Yu, Agnes Wong, and Robin Yip. 2013. "Quantifying the impact of construction waste charging scheme on construction waste management in Hong Kong." *Journal of construction engineering and management* 139 (5):466-479.

Saghafi, Mohammad Djavad, and Zahra Alsadat Hosseini Teshnizi. 2011. "Building Deconstruction and Material Recovery in Iran: An Analysis of Major Determinants." *Procedia Engineering* 21 (0):853-863. doi: http://dx.doi.org/10.1016/j.proeng.2011.11.2087.

Sassi, Paola. 2008. "Defining closed-loop material cycle construction." *Building Research & Information* 36 (5):509-519. doi: 10.1080/09613210801994208.

Shen, LY, Vivian WY Tam, CM Tam, and D Drew. 2004. "Mapping approach for examining waste management on construction sites." *Journal of construction engineering and management* 130 (4):472-481.

Sheskin, David. 2007. *Handbook of parametric and nonparametric statistical procedures*. 4th ed. Boca Raton: Chapman & Hall/CRC.

Teo, MMM, and Martin Loosemore. 2001. "A theory of waste behaviour in the construction industry." *Construction Management & Economics* 19 (7):741-751.

TWMO. 2014. Tehran Waste Generation Report. Tehran, Iran: Tehran Waste Management Organisation (available at: http://pasmand.tehran.ir).

Wu, Zezhou, Ann T. W. Yu, Liyin Shen, and Guiwen Liu. 2014. "Quantifying construction and demolition waste: An analytical review." *Waste Management* 34 (9):1683-1692. doi: http://dx.doi.org/10.1016/j.wasman.2014.05.010.

Yean Yng Ling, Florence, and Dinh Song Anh Nguyen. 2013. "Strategies for construction waste management in Ho Chi Minh City, Vietnam." *Built Environment Project and Asset Management* 3 (1):141-156.

Yuan, Hongping, and Liyin Shen. 2011. "Trend of the research on construction and demolition waste management." *Waste management* 31 (4):670-679.