

# From green buildings to living buildings? Rating schemes and waste management practices in Australian educational buildings

From green  
buildings to  
living  
buildings?

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## Abstract

**Purpose** – There is an increasing level of recognition of the pressing issues associated with climate change and resource depletion. As a result, it is well recognised that higher education institutions bear responsibilities to promote “sustainable development”. Many universities have adopted green building practices in the construction of their building infrastructure. A variety of Green Building Rating Tools (GBRTs) have been designed to facilitate green building developments. Thus, the aim of this research is to identify mechanisms to improve current GBRTs in terms of waste management (WM) practices by using green star accredited educational buildings in Australia.

**Design/methodology/approach** – A qualitative approach was adopted in this study to achieve the research aim by conducting three case studies of educational buildings in South Australia. Thirty three interviews were carried out in a face-to-face, semi-structured manner and project documentations were reviewed. The participants were asked to provide their expert opinions on the GS initiative and its ability to minimise waste generation, the impact of the GS initiative on solid WM practices and problems associated with the implementation process of the GS initiative. Data was analysed using code-based content analysis using the NVivo software package. Tables and figures were used as the visualization technique to present an expedient understanding in a holistic manner.

**Findings** – Findings showed that the Green Star (GS) initiative drives change in the way current practices are performed in the Australian construction industry. However, this study revealed that WM targets outlined in the GS initiative are not challenging enough. Thus, suggestions are provided in this research to improve the WM aspects of GS initiatives by looking beyond a focus on “sustainability” and “waste minimisation” towards a focus on regenerative environments.

**Originality/value** – These findings are valuable for practitioners and policymakers seeking to improve WM practices and to address issues associated with climate change and resource depletion.

**Keywords** Australia, Building rating tools, Green buildings, Waste generation, Waste management

**Paper type** Research paper



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## 1. Introduction

The growing demand for higher education in Australia has created a significant demand for the development of university infrastructure to meet current students' needs (Norton and Cakitaki, 2016). Most universities have integrated sustainable construction practices into their works to a certain degree (Leal Filho *et al.*, 2018; Sturlaugson *et al.*, 2019; Van Weenen, 2000) due to the increased public recognition of the need to address issues associated with climate change, resource depletion and the level of waste generation in construction projects (Yuan *et al.*, 2012; Lee and Shepley, 2019). Kibert (2013, p. 8) defines "sustainable construction" as "the creation and responsible management of a healthy built environment based on resource efficient and ecological principles". As a result of the current demand for sustainability and sustainable construction, green building development has gained the attention of researchers and industry practitioners (Darko and Chan, 2016; Wu *et al.*, 2016a; Illankoon *et al.*, 2017; Doan *et al.*, 2017). According to Kibert (2013, p. 8), green buildings can be defined as "healthy facilities designed and built in a resource-efficient manner, using ecologically based principles". Green designs are closely associated with green building rating tools (He *et al.*, 2018). Green building rating tools (GBRTs) are used to measure the sustainability performance of green buildings (Doan *et al.*, 2017; Shan and Hwang, 2018; Wu *et al.*, 2016b; Nguyen and Rockwood, 2019). The green education facilities are future proofed assets that attract awards and grants while enhancing the client's prestige as they provide a healthy and productive place to learn and teach; low operating costs; energy savings; environmentally friendly facilities with hands-on learning opportunities (Green Building Council Australia, 2020). Similarly, Golbazi *et al.* (2020) found that there are positive impacts on students' learning from the improved living conditions in green educational buildings. There are a number of criteria in GBRTs and WM is one of them (Wu *et al.*, 2016b). Illankoon and Lu (2020) argued that WM related credits are least investigated in green buildings. Shen *et al.* (2004, p. 473) define construction waste as:

Building debris, rubble, Earth, concrete, steel, timber, and mixed site clearance materials, arising from various construction activities ...

By implementing proper WM practices, the construction industry can gain economic, quality and productivity benefits (Hwang and Bao Yeo, 2011). However, existing studies on green buildings and GBRTs have mainly focused on implementation of the green building process, certification of green buildings, advanced technologies used in green buildings and energy performance of green buildings (Darko and Chan, 2016). By contrast, very few studies have addressed the WM aspect of GBRTs. Therefore, the significance of WM needs to be better understood so that stakeholders are encouraged to achieve WM related goals (Manowong, 2012). While green building initiatives may be useful in encouraging people to focus on minimising the negative impacts of construction, more recent initiatives like the Living Building Challenge have focused on encouraging projects to have a net beneficial impact through the design of regenerative environments. This research utilises a case study approach to identify mechanisms to improve current GBRTs in terms of WM practices by using green star accredited educational buildings in Australia.

## 2. Literature review

### 2.1 Movements towards green building in the higher education sector

The higher education sector contributes significantly to the national economy of Australia, having generated nearly \$30 billion revenue in 2014 (Norton and Cakitaki, 2016). The rapid growth of student enrollments in the past few years in Australian universities demands new infrastructure to accommodate students' needs (Norton and Cakitaki, 2016). Acknowledging the current pressures on resource depletion and climate change, many universities have sought to integrate a focus on "sustainability" or "sustainable development" into university policies

and practices (Van Weenen, 2000; Lozano *et al.*, 2015). Furthermore, some researchers have argued that higher education institutions have a responsibility to promote sustainable development and should serve as exemplars for implementing sustainable construction (Alshuwaikhat and Abubakar, 2008; Amaral *et al.*, 2015). Reviewing several definitions of green buildings, Darko and Chan (2016) suggest that green buildings help to promote “sustainable development” by contractually binding the construction industry to sustainable development. Recent years have seen a growing interest of universities in creating green campuses through constructing green buildings (Alshuwaikhat and Abubakar, 2008; Amaral *et al.*, 2015). In his research on Community Social Marketing, McKenzie-Mohr (2011) pointed out that public commitments have a considerable impact on behaviour change and written commitments are more effective than verbal commitments. Thus, it can be argued that green building tools have been developed to help ensure such public claims are supported by evidence.

## 2.2 Green buildings rating tools

Green buildings have been argued to offer comfortable, productive and improved indoor environments by minimising resource usage compared with conventional buildings (Mokhlesian and Holmén, 2012). Darko *et al.* (2017) and Zhang *et al.* (2018) also suggest that disruptive effects of construction activities on the environment can be minimised by adopting green building practices. A range of green building rating tools (GBRTs) have been developed and widely adopted to test such claims and measure the sustainability performance of green buildings (Wu *et al.*, 2016b; Doan *et al.*, 2017; Olanipekun *et al.*, 2018; Darko *et al.*, 2019).

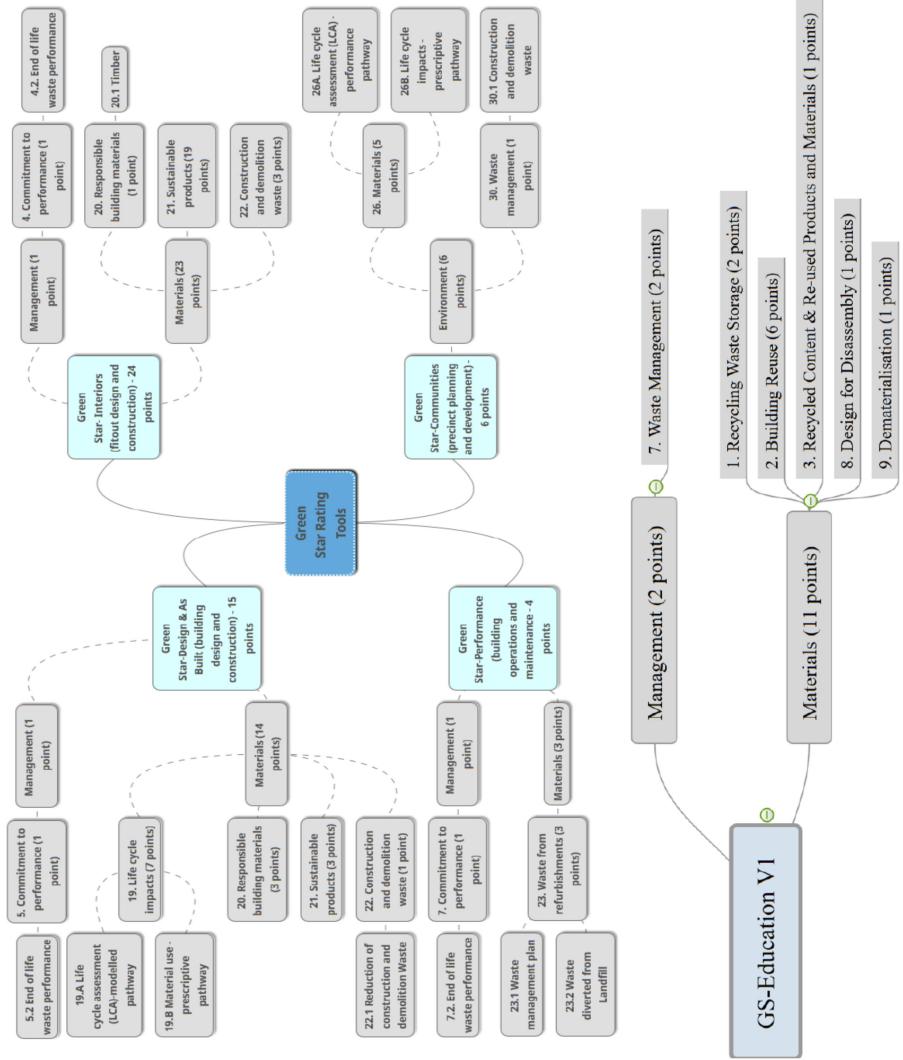
The Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED) method are internationally recognised construction-related assessment tools for evaluating the performance of green buildings (Mokhlesian and Holmén, 2012; Doan *et al.*, 2017; Tam and Hào, 2019). Green Star is Australia's first comprehensive rating system for evaluating the environmental design and performance of Australian buildings. The GS environmental rating system for buildings was developed by the Green Building Council of Australia (GBCA) in 2003. Green Star has been designed and developed based on the BREEAM and LEED tools by establishing individual environmental measurement criteria relevant to the Australian marketplace and environmental context.

## 2.3 Focus on waste management in green star rating tool

According to the Green Building Council of Australia (2013), green rating tools cover management, indoor environment quality, energy, transport, water, materials, land use and ecology, emissions and innovation. GS-communities, GS-design as built, GS-interiors and GS-performance are the four main rating tools available under the GS for certification. GS-education V1 rating tool is used for educational buildings. The following diagram (Figure 1) highlights the direct points for construction WM in GS rating tools.

As shown in Figure 1, the “management” and “materials” categories of GBRTs are the main categories covering construction WM. Out of the four rating tools outlined in Figure 1, GS-interiors allocates the highest number of points for WM. Out of 110 points, 15 points are related to construction WM in GS-design and as-built tool. In GS-communities and GS-performance, less than 10 points are allocated for construction WM. Thirteen points are allocated in GS-education V1 rating tool for WM. A similar finding can be found in a study conducted by Illankoon *et al.* (2017) in relation to other green building rating tools. They highlighted that in LEED 12 credit points, BREEAM 18 credit points, Green Mark 4 credit points, GBI (Green Building Index) 6 credit points, BEAM plus (Building Environmental Assessment Method) 12 credit points, IGBC (Indian Green Building Council Rating) 5 credit points and CASBEE (Comprehensive Assessment System Built Environment Efficiency) 4 credit points are allocated for waste and pollution. This was highlighted in the study

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**Figure 1.**  
Direct points for construction and demolition waste management in Green Star rating tools ([Green Building Council Australia, 2017](#))

conducted by [Zuo et al. \(2014\)](#), who pointed out the performance-oriented nature and greater focus on the operational stage of buildings in GBRTs when compared with the construction stage. Similarly, [Chen et al. \(2015\)](#) pointed out that the assessment criteria of building rating tools are heavily focused on the energy efficiency of buildings.

#### *2.4 Challenges in implementing green building initiative and using GBRT*

Researchers have identified several challenges in implementing green building initiatives and using GBRTs. For example, [Jagarajan et al. \(2017\)](#) have identified financial resources, green building professionals, policy support, green development quantification, green awareness, communication, internal leadership, green material and technology as main factors affecting successful implementation of green building projects. [Hwang et al. \(2017\)](#) highlighted the high-cost of green building projects due to the expensive nature of green technologies and materials; high-cost in research and development activities; and limited availability of experts and information. Similarly, [Amaral et al. \(2015\)](#) have criticised green building initiatives for the absence of systematic and continuous quality improvements. [Hwang and Ng \(2013\)](#) identified that the top ten challenges faced by project managers in managing green construction projects are: lengthy pre-construction processes; lack of subcontractors who provide green construction services; uncertainty with green materials and equipment; high cost of green materials and equipment; more meetings and coordination required with green consultants and engineers; frequent alterations and variations to the design during the construction process; difficulty in understanding the green specifications in the contract details; unforeseen circumstances in project execution; planning of non-traditional construction sequences and planning of different construction techniques. Some of these challenges can impact on WM practices due to alterations in designs and unfamiliarity of new material and technology usage. There are implications on the related cost and alternative materials (e.g. [Lu et al., 2019](#); [Tam et al., 2019](#)).

#### *2.5 Living building challenge and the concept of net positive waste*

The Living Building Challenge looks beyond a focus on efficiency, harm minimisation and “sustainability” by promoting a focus on restorative, regenerative, and net positive impacts of construction practices ([International Living Future Institute, 2016](#)). The Living Building Challenge addresses seven imperatives including place, water, energy, health and happiness, materials, equity and beauty ([International Living Future Institute, 2016](#)). As highlighted by [Ge \(2014\)](#), the Living Building Challenge improves the quality and comprehensiveness of Triple Bottom Line reporting. The concept of net positive waste is discussed under the materials imperative and encourages elimination of waste from the whole life of the buildings and integration of waste back into an industrial loop or a natural nutrient loop ([International Living Future Institute, 2016](#)). The following table ([Table 1](#)) highlights the requirements outlined in the Living Building Challenge in relation to net positive waste.

As outlined in [Table 1](#), the Living Building Challenge encourages waste elimination and achievement of high waste diversion rates in construction projects. Similarly, the ultimate aim of the Living Building Challenge is to “envision a future that is Socially Just, Culturally Rich and Ecologically Restorative” ([International Living Future Institute, 2016](#)). [Ge \(2014\)](#) pointed out that the “materials” component of the Living Building Challenge has low impact on the social aspects, medium impact on the economic aspects and high impact on the environmental aspects of Triple Bottom Line reporting. While some researchers differentiate green buildings from conventional buildings due to their high environmental performance, [Cole \(2012\)](#) has argued that there is a need to move from green design to regenerative design and that the Living Building Challenge can be used to facilitate this process. According to [Cole \(2012\)](#), p. 39), regenerative design focuses on “a co-evolutionary, partnered relationship

between humans and the natural environment, rather than a managerial one that builds, rather than diminishes", social and natural resources. Thus, the concepts used in the Living Building Challenge could potentially be used to improve green building practices.

### 3. Research method

[Yin \(2009\)](#) argues that, if research requires an extensive and in-depth understanding of a particular issue, case studies will be more relevant than other methods. Thus, case studies were used as the primary data collection method in this research.

The case studies were selected from educational buildings as the educational sector has been identified as a pioneer in creating sustainable buildings for current and future generations ([Aghimien et al., 2018](#)). According to [Yin \(1994\)](#), the number of cases in a case study could vary from one to eight depending on the nature of the research. Thus, three case studies were selected from recently completed five and six Star GS educational building projects in South Australia, which achieved more than a 90% waste recycling rate considering flexibility and accessibility of project information and project participants. A brief description of the selected cases is provided in [Table 2](#).

In this research documentation and interviews were selected as the most accessible and reasonable data collection tools due to the nature of the research. Documentation included administrative documents. The interviews were carried out in a face-to-face, semi-structured

**Table 1.**  
Requirements of net  
positive waste  
([International Living  
Future Institute, 2016](#))

Phase	Requirements
Design	Apply adaptive reuse principles or use at least one salvaged material per 500 square meters of gross building area Prepare materials conversation management plan Consider durability in product specification
Construction	Prepare a pre-building audit for reuse or donation of materials where applicable Optimisation of resources and waste material collection Minimum requirements of diversion of waste materials – metal 99%, paper and cardboard 99%, soil and biomass 100%, rigid foam, carpet and insulation 95%, all other waste 90%
Operation	Prepare a collection plan for consumables and durables
End of Life	Plan for adaptive reuse and deconstruction

**Table 2.**  
Brief description of  
case studies

	Case study A	Case study B	Case study C
Building type	Educational	Educational	Educational
Number of storeys	Eight-storey building with a basement	Three-storey building	Eight-storey building
Total gross floor area	14,497 sqm	7,300 sqm	12,480 sqm
Total cost of construction	\$100 million	\$48 million	\$82.5 million
Project duration	2007–2010	2009–2011	2011–2014
Procurement method	Traditional procurement – lump-sum contract	Management contracting	Management contracting
Green Star rating	Six star Green Star for both education design v1 and education as-built v1	Five star Green Star for education design v1	Five star Green Star for education design v1
Waste recycling rate	95%	98%	99%

manner. The main questions asked from case study participants included their expert opinions on the GS initiative and its ability to minimise waste generation, the impact of the GS initiative on solid WM practices and problems associated with the implementation process of the GS initiative. The duration of an interview was around one hour. Interviews were conducted with key project participants from each case study's construction project team. A brief description of the interviewees is provided in [Figure 2](#).

Content analysis was applied to the qualitative data using the NVivo software package. Tables and figures were used as the data-displaying technique to present an expedient understanding in a holistic manner.

#### 4. Key findings

##### 4.1 Green star initiative and its ability to minimise waste generation

Case studies used in this research were accredited under the GS-Education V1 rating tool. According to this rating tool, solid WM practices are covered under Management 7 – “waste management” (weighting is 1.4% of the overall tool) and “materials” (weighting is 10% of the overall tool). As shown in [Table 3](#), mixed responses were received from the interviewees on the GS initiative.

Some case study participants highlighted that there were different motivations for using the GS building rating tools in the construction industry. Some clients see it as a point-scoring exercise leading to marketing benefits, while others see it as a useful tool to guide the design towards sustainability. Interviewees further added that even though people are not agreed on every point in the GS rating tool, overall, it drives change in the industry. . However, some interviewees pointed out that solid WM receives the least attention in GS building rating tools in comparison to the attention paid to energy consumption.

Some interviewees suggested that the GS initiative encouraged project participants to consider WM in design and documentation processes. They also suggested that GS initiatives helped to change the WM behaviours of designers and other consultants involved in the case study projects. Supporting this view, Client's Project Manager B added that the “GS movement has come a long way to shifting consultants and their behaviours around the selection of materials and systems and considering waste in their design and documentation outcomes”. However, Design Architect B commented that the GS rating system does not have a direct impact on design as it does not consider proactive WM practices.

Interviewees pointed out that the GS initiative promotes the setting of WM targets in construction projects. Contractor's Project Manager A revealed that, due to GS requirements, they made conscious efforts to minimise waste generation by tracking recycling targets and careful selection of materials which fulfil the criteria in specifications. Project Architect A highlighted that the GS initiative set solid targets in WM, adding that: “GS was able to formalise all that and actually set a benchmark rather than just having loose figures out there that people may or may not need to comply with”. As mentioned by Quantity Surveyor A, the target of achieving a six star GS accreditation forced designers and contractors to build the building in the most efficient way. They said that “if it was a 4-star building, I'm sure they would not put the effort in because horses for courses . . .”. Contractor's Project Manager B also stated that WM requirements were highlighted in the contract and most recycled materials used in Case Study B were purely because of the GS initiative.

However, Facilities Manager B added that, as they already have good WM strategies in place in Case Study B, the GS initiative did not affect the way they manage their waste. Client's Project Manager (Pre-Contract) C said that WM practices were mostly driven by the GS initiative. However, Facilities Manager C added that, even without implementing the GS initiative, they would have implemented WM practices in Case Study C, as the client was committed to sustainable construction and best practices. Contractor's Project Manager C

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**Figure 2.**  
Description of case study representatives

	Case study A	Case study B	Case study C	From green buildings to living buildings?
<i>Positive points</i>				
Drives change in the industry	✓			
Encourages setting targets for waste management	✓	✓		
Beneficial for waste management and control	✓			
Promotes use of recycled materials and materials recycling	✓			
Influences materials selection	✓			
Facilitates healthier working environment due to use of less volatile materials in carpets and furniture, use of fresh air in air-conditioning systems	✓			
Not the perfect tool but it was the only tool that was good	✓			
Highly effective in affecting cultural change		✓		
Affects builders' waste management practices		✓		
Improves the efficiency of the building			✓	
Promotes sustainable practices			✓	
Improves the design aspects of the building			✓	
<i>Negative points</i>				
More focus on energy saving	✓			
Solid waste management receives least attention		✓		
Involves enormous amount of documentation	✓	✓		
Time consuming and hence expensive process	✓	✓	✓	
Does not have similar impact or benefits for all stakeholders	✓	✓	✓	
Point scoring exercise which leads on to some marketing benefit	✓			
Does not encourage proactive waste management practices		✓		
Easily achievable waste management target	✓		✓	

**Table 3.**  
Positive and negative aspects of Green Star process

said that the GS process was not a driver for implementing WM practices and added that “no, it would not have mattered, we still would have recycled anyway”. Similarly, Contractor’s GS Coordinator C said that as they have their own WM criteria, there was less impact from GS for them due to its less challenging nature. However, they agreed that the GS process helped to contractually oblige subcontractors to comply with WM practices.

#### 4.2 Impact of the green star initiative on material selection

As highlighted by the case study interviewees, material selection was carefully done in case study projects due to the implementation of the GS initiative. As shown in [Table 4](#) a number of different factors were considered in the case studies when it comes to the material selection.

Out of these three case studies, Case Study A has considered more factors in material selection compared to the other two cases. However, when comparing waste recycling rates, Case Study C achieved the highest recycling rate out of three case studies.

As highlighted by both Quantity Surveyor A and Contractor’s Project Manager B, clients of Case Study A and Case Study B wanted to use recycled materials in their projects even though they were expensive due to the implementation of the GS initiative. Contractor’s Project Manager A commented that, as this is a six Star GS building, they had to be more conscious about materials selection and they had to look at the chain of custody to make sure all materials fulfilled GS criteria. Moreover, most of the materials in Case Study A were selected based on third-party certification, such as GECA (Good Environmental Choice Australia), which utilises environmental management plans and WM strategies in the materials production process.

Similarly, Project Architect B pointed out that they carefully selected materials for this project by considering their recycled content and their ability to be recycled. In Case Study A,

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Materials selection	Case study		
	A	B	C
Evaluated different materials options	✓	✓	✓
Evaluated the cost and benefits of recycled materials	✓		
Avoided using hazardous materials	✓		✓
Used low volatile organic compound (VOC) materials	✓	✓	✓
Reduced polyvinyl chloride (PVC) usage	✓		✓
Sustainable fabric selection	✓		✓
Used locally produced materials	✓		
Used recycled materials	✓	✓	✓
Used durable and easy-to-clean materials in finishes			✓
Minimised materials wastage (e.g. minimised ceiling finishes)	✓	✓	✓
Controlled packaging	✓		✓
Considered demountability of materials		✓	
Considered chain of custody of materials and environmental certification		✓	
Recycled materials	✓	✓	✓

**Table 4.**  
Materials selection in case study projects

they have used a minimum of 90% post-consumer recycled steel in reinforcement and even reused Jarrah timber from the roof of the demolished building in features of aesthetic appearance in the new building. In Case Study B, they used recycled timber, reconstituted rubber flooring, fly ash in concrete, recycled reinforcement, and steel. In the Case Study C, they used fly ash in concrete, used carpets and Marmoleum flooring which has recycled contents. The following table (Table 5) highlights the types of recycled and recyclable materials used in the case study projects.

Type of recycled and recyclable materials	Case study		
	A	B	C
<i>Use of recycled materials in case studies</i>			
Fly ash in concrete	✓		✓
Reinforcements made out of recycled steel	✓	✓	✓
Recycled contents in steel	✓	✓	✓
Recycled timber	✓	✓	✓
Recycled materials in flooring materials	✓	✓	
Recyclable contents in workstation materials	✓		✓
GECA-certified furniture	✓		
<i>Reusable and recyclable materials used in case studies</i>			
Topsoil			✓
Concrete and bricks	✓	✓	✓
Façade materials	✓		✓
Glass	✓		✓
Aluminium	✓		✓
Copper			✓
Steel		✓	✓
Timber	✓		✓
Carpet tiles	✓		
Partitions	✓		
Workstation materials	✓		
Formworks			
Furniture		✓	
Polystyrene		✓	
Plasterboard		✓	
Paper and cardboard	✓	✓	✓

**Table 5.**  
Types of recycled and recyclable materials used in case study projects

Thus, results show that the GS building rating tool had a direct impact on the material selection in case study projects.

#### *4.3 Impact of the green star initiative on onsite solid waste management practices*

All case study participants agreed that GS affects the way that builders manage waste on site. According to Contractor's GS Coordinator C, everyone involved in Case Study C was aware of WM requirements and compliance with the WMP was contractually driven. They also pointed out that they had post-tender meetings with subcontractors to communicate about the contract, including its GS and WM requirements. Senior Site Manager A also stressed that most WM practices were implemented as a result of the commitment to GS even though managing waste was an expensive process. They said that "I think personally it was just because of GS, yeah, otherwise generally things will just go in one bin".

As shown in [Table 2](#), a 99% recycling rate was achieved in Case Study C and the aims and objectives of the waste management plan (WMP) used in the Case Study C are shown in [Figure 3](#).

In case study C there were arrangements with some suppliers to take back their packaging materials as well. The management contractor of Case Study C had a WMP, and environmental management and sustainability plan. Key elements extracted from the environmental management plan were included in the project-specific site induction training provided for all employees, subcontractors and site workers prior to commencing work. While these findings suggest that GS has positive impacts on WM practices in the case study projects, participants also highlighted some issues with the process.

#### *4.4 Problems associated with the implementation of green star initiatives*

Interviewees raised a number of problems associated with implementation of the GS initiative including the time-consuming and expensive nature of the process; an insufficient focus on life-cycle assessments and a full chain of custody of waste; easily achievable WM targets and the potential to encourage a focus on point scoring over sustainable construction practices.

Interviewees highlighted that from an administrative point of view, achieving GS ratings is time-consuming and expensive. For example, Design Architect A mentioned that they

Aims
<ul style="list-style-type: none"><li>▪ Achieve company objectives and targets of at least 95% recycling of waste</li><li>▪ Support the South Australia's Strategic Plan 2007 target of reducing waste to landfill by 25% by 2014</li><li>▪ Promote the implementation of the waste management hierarchy, improve resource recovery and reduce waste going to landfill</li><li>▪ Help avoid or minimise the risks of environmental harm from waste management.</li><li>▪ Control, minimise and salvage waste at the construction site</li><li>▪ Provide improved options for regulating illegal dumping and inappropriate stockpiling</li></ul>
Objectives
<ul style="list-style-type: none"><li>▪ Eliminate or minimise the amount of waste materials brought to the site</li><li>▪ Sort the types of waste and store waste for appropriate disposal</li><li>▪ Dispose of all waste practicable by recycling</li><li>▪ Control toxic and dangerous waste</li><li>▪ Use relevant local recycling facilities and firms</li><li>▪ Minimise landfill waste disposal</li><li>▪ Introduce and make all subcontractors working on site aware of waste</li><li>▪ Adopt and implement the WMP throughout the project. Monitor performance and review plan as required</li></ul>

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**Figure 3.**  
Aims and objectives of  
waste management  
plan of Case Study C

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completed extensive research and documentation processes which were different to what is done in an ordinary project, adding that: “... on that job, we spent perhaps three months more than we would normally do. Just simply in the paperwork and the paperwork related to the GS was really significant”. Similarly, Project Architect C said that the implementation of the GS initiative in construction projects is expensive for clients and is time-consuming, requiring an onerous amount of work that has to be done by both the design and construction management teams. However, Sustainability Consultant A commented that current targets in the GS tool can be achieved easily and that it is necessary to make the process more stringent. Thus, they urged the importance of updating current requirements in GS by focusing more on life-cycle assessments, and that a full chain of custody of the waste needs to be evaluated. They stated: “so not just removing from the site and claiming that it's recycled and diverted from landfill but maybe some more verification on exactly how it is being reused”. Waste Contractor C said that, in order to achieve maximum points for WM in the GS rating, they only have to recycle 80% of waste which is low compared to their practices. They added that it is necessary to have higher recycling rates to challenge people to improve their commitment. The following table (Table 6) highlights the statistics related solid waste generation and waste recycling in case study projects, which supports the above-mentioned argument.

Some interviewees highlighted that there was not a genuine intention to minimise waste in implementing GS, even though it has helped to minimise waste generation, as it is based on a point scoring system. Supporting this, Project Architect B added that “the motivation was more to get the points than perhaps to minimise waste for minimising waste's sake”. Sustainability Consultant B also said that as a result of GS requirements, they set up WM requirements for the management contractor, but as they mentioned “there wasn't a large emphasis on ‘designing out’ waste from the project”. Thus, it can be argued that it is necessary to address the above-mentioned problems in order to implement better WM practices in GS projects.

## 5. Discussion

There were mixed responses from interviewees on the GS initiative. Some case study participants highlighted that, even though WM practices were mostly driven by the GS initiative, the rating scheme did not support genuine motivations towards waste

**Table 6.**  
Solid waste generation  
and waste recycled  
percentages in  
construction stage of  
case studies

Waste type	Case study A		Case study B		Case study C	
	Tonnes generated	% tonnes recycled	Tonnes generated	% tonnes recycled	Tonnes generated	% tonnes recycled
Bitumen			542.34	100%		
Concrete	44.89	100%	405.88	100%	16.95	100%
Clean green			27.94	100%		
Mulch			192	100%		
Mixed C&D			9.44	86.02%		
Steel	18.96	100%			46.62	100%
Timber	110	100%	3.23	100%		
Mix recycled	586.19*	94.2%	317.70	92.45%		
Cardboard/			8.39	100%		
Paper						
General					1044.61	99%
waste						
Landfill	0.9	0%				
Total	760.9	95.4%	1506.92	98.31%	1108.18	99.06%

minimisation, as the GS initiative is based on a point scoring system that risks becoming an exercise in ticking boxes. Likewise, solid WM receives the least attention in the GS rating system in comparison to the attention paid to energy consumption in construction projects. This was also highlighted in [Figure 1](#) and in some GBRTs points allocated for construction WM were less than 10% of the overall points.

Moreover, the GS initiative acted as a driver for implementing WM practices in the case study projects even though managing waste is considered to be an expensive process. Some case study interviewees believed that implementation of WM practices was solely driven by the GS initiative. These findings somewhat contradict the findings of a study conducted by [Manowong \(2012\)](#), which highlight that profit maximisation is more important for clients than construction WM. Thus, it can be argued that when WM is embedded in public commitment, clients tend to invest in WM in their projects. Therefore, it can be argued that public commitment can be used as a tool to improve WM practices in construction projects.

The GS initiative also encouraged case study participants to set WM targets, integrate WM in the design and motivated project participants to comply with WM practices. Similarly, due to GS requirements, project participants of the case studies made conscious efforts to minimise waste generation by tracking recycling targets and careful selection of materials to fulfil the GS criteria in specifications. However, as highlighted by case study participants, WM targets outlined in the GS process are often not challenging enough and those can be easily achievable as shown in [Table 6](#). There is therefore, potential to move beyond a focus on sustainability and harm minimisation in construction, towards a focus on restorative and regenerative environments, as for example through the aims of net positive waste outlined in the Living Building Challenge. This could help to achieve more environmentally friendly practices in GS projects as achievement of net positive waste demands the firm requirements in WM practices focusing on design, construction, operation and end of life of buildings as outlined in [Table 1](#). This could help to overcome some of the problems highlighted by interviewees in relation to GS process as outlined in [Section 4.4](#). Thus, it is necessary to integrate more holistic and ambitious requirements of WM practices in the GS process, like the Living Building Challenge requirements of net positive waste. The GS process also helped to contractually oblige subcontractors to comply with WM practices. Similar findings were reported from in a study conducted by [Darko and Chan \(2016\)](#), who argued that green building helps to promote sustainable development by contractually binding the construction industry to sustainable development commitments. Some interviewees pointed out that, unless there is a requirement to comply with the GS rating system or another accreditation program, there is less motivation for construction practitioners to set waste reduction targets in construction projects. However, some case study interviewees stated that they already had effective WM strategies in place and the GS initiative did not affect the way that they managed waste in construction projects. Thus, it can be argued that when organisations are committed and have previously implemented actions for WM in construction projects, they tend to take necessary actions to minimise waste generation in their future projects.

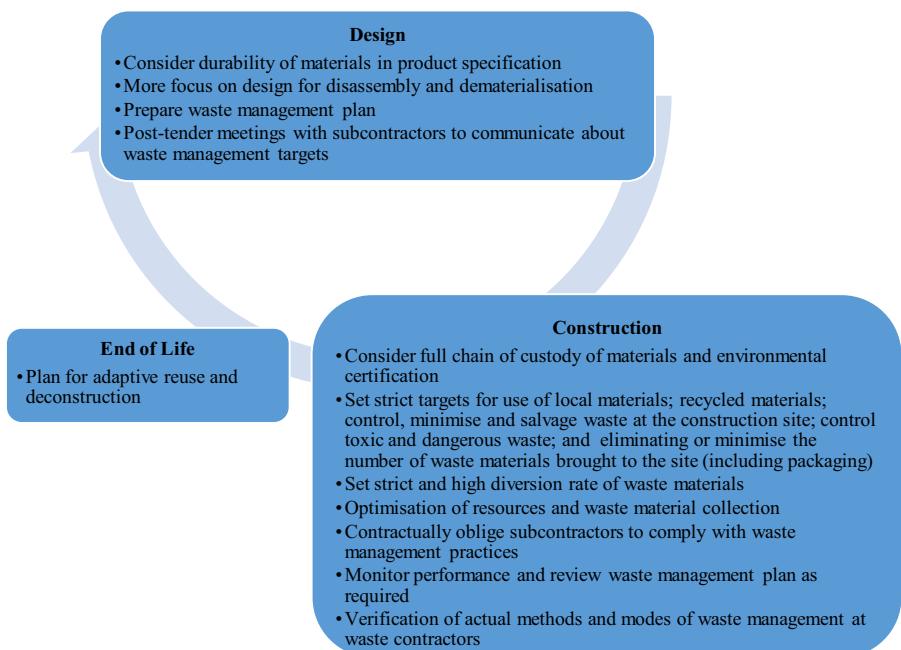
The GS initiative helped to change the approaches of designers and other key consultants involved in the case study projects in relation to selecting materials and systems considering waste in their design and documentation process, setting solid WM targets and making conscious efforts to minimise waste generation by tracking recycling targets. As most project participants in the case study projects had previous experience working with GS projects, an appropriate WM culture was embedded with their practices and it was only necessary to refine the WM culture.

However, the GS initiative involves an enormous amount of documentation and does not have the same impact on or benefits for all stakeholders. The negative impacts of the GS initiative, such as the process being time-consuming and involving high costs, are in line with

the findings of the study conducted by [Hwang et al. \(2017\)](#). These results suggest that, even though there is commerciality in the GS initiative, the upfront concerns about materials and waste are a good outcome of the GS process. The following diagram ([Figure 4](#)) highlights the suggested changes to improve WM aspects of GS initiative by integrating the key findings of this research and requirements of net positive waste in Living Building Challenge.

## 6. Conclusions

The research resulted in mixed responses from research participants in relation to the role of the GS initiative in minimising waste generation in construction projects. Findings of this research highlight that solid WM receives less attention in GS building rating systems in comparison to the attention paid to energy consumption. Irrespective of the marketability and commerciality of GS process, findings suggest that being concerned about materials and waste upfront is one positive benefit of the GS process. The GS initiative also encouraged consultants to consider WM in the design and documentation process, as well as motivating project participants to comply with WM practices. This suggests that GBRTs can be used to change the WM culture of construction projects. Furthermore, it was found that once construction organisations are committed to implementing WM practices in their projects their commitment tends to extend into other projects. However, the findings of this research highlight the necessity of improving the GS process by setting more challenging WM targets, and evaluating the full chain of the custody of waste, while making the application process less time consuming and expensive. The results suggest there is a need to move beyond a focus on sustainability and harm minimisation towards a focus on restorative and regenerative environments, through for example, the focus in the Living Building Challenge on net positive waste by putting waste back into an industrial or natural nutrient loop.



**Figure 4.**  
Mechanisms to  
improve construction  
waste management  
aspects of Green Star  
initiative

The findings of this research support arguments about the importance of mechanisms to ensure projects are meeting their public commitments to enhance WM practices in construction projects. By implementing the recommendations of this research, policymakers and construction practitioners can enhance their current WM practices and not only help reduce the negative environmental impact of construction activities, but also look towards the design and implementation of regenerative designs. Further research studies could focus on the implications of such an approach in terms of project and implementation costs and methods of optimising the documentation process of GS initiative.

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