# Implementing a circular economy in regional Australia

# who bears the economic costs in construction projects?

Mathur, Deepika; Jayasinghe, Maneka; Zander, Kerstin K.

*Published in:*
Urban Research and Practice

*DOI:*
10.1080/17535069.2025.2499633
10.1080/17535069.2025.2499633

Accepted/In press: 01/01/2025

*Document Version*
E-pub ahead of print


Urban Research & Practice

ISSN: 1753-5069 (Print) 1753-5077 (Online) Journal homepage: www.tandfonline.com/journals/rurp20

# Implementing a circular economy in regional Australia: who bears the economic costs in construction projects?

**Deepika Mathur, Maneka Jayasinghe & Kerstin K. Zander**

URBAN RESEARCH & PRACTICE
https://doi.org/10.1080/17535069.2025.2499633

Routledge
Taylor & Francis Group

OPEN ACCESS   Check for updates

# Implementing a circular economy in regional Australia: who bears the economic costs in construction projects?

Deepika Mathur[a], Maneka Jayasinghe[b] and Kerstin K. Zander[a]

[a]Northern Institute, Charles Darwin University, Australia; [b]Faculty of Arts and Society, Charles Darwin University, Australia

**ABSTRACT**
Implementation challenges and the lack of regionally focused interventions are some critiques of circular economy models in the literature. This study examines barriers to adoption of circularity in construction projects through a case study set in the regional town of Alice Springs, Australia, using data from in-depth interviews of various stakeholders (clients, contractors, recyclers etc.). Examining construction waste through a socio-technical transition lens highlighted the impact of clients' decision-making, high transport costs and prevalence of small businesses on circularity in regional towns. These findings demonstrate the need for developing context-based solutions for incentivising uptake of circular economy initiatives.

**ARTICLE HISTORY**
Received 20 June 2024
Accepted 25 April 2025

**KEYWORDS**
Circular economy; construction waste; sustainable transitions; waste transport; regional town

## 1. Introduction

Globally, waste from building construction can constitute up to 30% of the total waste generated (Soto-Paz et al. 2023). The circular economy approach is a regenerative, closed-loop model that treats waste materials as valuable resources, aiming to reduce waste through reuse or recycling rather than sending materials to landfill (EMF 2017). End-of-life looping of materials can increase resource efficiency and reduce waste, particularly as certain materials become scarcer and more expensive to obtain (Akanbi et al. 2018; Benton, Hazell, and Hill 2017; Cruz Rios et al. 2022).

Despite the clear benefits of and potential of circular economy in the construction sector, its implementation remains rare (Brambilla et al. 2019; Ritzén and Sandström 2017). This is partly because of significant legislative, regulatory, economic and technological challenges which require drastic changes in waste management practices and business operations (e.g. Guerra and Leite 2021; Salmenperä et al. 2021). Additionally, it is because of negative societal attitudes towards waste reduction and reuse (Jaeger-Erben et al. 2021; Lieder and Rashid 2016) and a lack of awareness or interest of the public, sometimes influenced by cultural barriers (Bilal et al. 2020; Hart et al. 2019). Economic challenges include the high upfront costs (Urbinati, Franzò, and Chiaroni 2021), low costs of virgin materials (Campbell-Johnston et al. 2020), low costs of

**CONTACT** Deepika Mathur Deepika.mathur@cdu.edu.au

disposal to landfill (Salmenperä et al. 2021) and uncertain markets for recyclable materials (Bao and Lu 2020; Charef, Lu, and Hall 2022). The technological barriers relate to lack of circularity in product design (Antwi-Afari et al. 2023), non-standardization of recycled materials (Campbell-Johnston et al. 2020; Kirchherr et al. 2018) and supply chain complexities (Charef and Emmitt 2021).

An important gap in the literature is the lack of specific case studies using a circular economy approach during the complete life cycle of construction projects (Hart et al. 2019). There is a lack of evidence of approaches targeting specific stages/elements of design and construction, such as recycling technology or material reuse or a particular construction practice or a particular stakeholder, rather than considering them as interconnected elements of a complete system. A building project involves many different stakeholders throughout its lifecycle from design to construction of the building. Each stakeholder (for example, client, architect, project manager, consultants and building contractors) makes decisions about the different stages occurring in a project such as design, contract management and construction technology used (Gerding, Wamelink, and Leclercq 2021). These decisions significantly influence the amount and type of waste generated and reused during construction. Existing studies on construction stakeholders have mainly discussed stakeholder perceptions of waste reduction or using recycled content (Z. Ding, Wang, and Zou 2016; S. Ding et al. 2022; Park and Tucker 2017; Teo and Loosemore 2001), a particular intervention such as landfill levy (Shooshtarian et al. 2020) or interactions between stakeholders (Barakat and Srour 2024). However, the main limitation of this approach is its emphasis on a particular stakeholder group and their experience of waste management across projects. This perspective overlooks the contextual factors of a particular project.

Another significant limitation in existing studies is the lack of context-specific case-studies examining how geographic location impacts circular economy in building projects. Most studies are based on empirical data from cities with high access to services, such as recycling. For example, Suzhou, China (Bao et al. 2019), Amsterdam, Utrecht and the Hague in the Netherlands (Campbell-Johnston et al. 2019). When data is collected from expert stakeholders, they are either metropolitan based circular economy experts (Charef and Lu 2021) or from top firms ranked by revenue (Cruz Rios et al. 2022). The location of regional towns, with limited access to recycling services, and small budgets are missing from the circular economy studies. Hence, the scale of adoption of circular economy in regional areas is still unknown.

As such, this research uses a case study of a small project in a regional town in Australia to understand the barriers present in regional Australian towns for participating in a circular economy. This is important because a circular economy approach is a priority for the Australian government for waste management and is actioned through the 2019 Waste Action Plan (Australian Government 2019). The state and local governments are aligning with the national directive by making circular economy a focus in their local waste management plans (Government of Western Australia 2020; Green Industries SA 2020; Northern Territory Government 2022). Nevertheless, there are very few examples in Australia, particularly in regional areas, that use a circular economy approach in building design and construction. Given Australia's vast geographical dispersion, there is a substantial divide between regional and metropolitan areas in terms of construction practices and infrastructure. While metropolitan areas benefit from advanced, densely connected infrastructure, regional areas often face challenges such as limited access to services, less developed roads, connectivity and limited scale of operations. As a result, the state and territory governments have included circular economy in their waste management plans without fully understanding the limitations of regional towns in adopting circular economy strategies.

The theory of socio-technical transitions is used in this study to examine ways regional towns can transition towards a circular economy. Sustainable transition studies discuss ways in which current society needs to change in order to respond to persistent environmental problems, such as climate change, energy, resource problems or biodiversity loss (Blattner 2020; Sovacool and Griffiths 2020). The socio-technical transitions framework is crucial in this research since it recognizes that achieving systemic transformation towards circularity requires more than just technological innovations. It also demands fundamental shifts in social practices, behaviours, policies and institutional frameworks. However, since socio-technical studies often overlook issue of scale and space, literature on waste mobilities is used here to examine how the geographic locations of buildings influence their transition to a circular economy (Davies 2012). This spatial aspect is important to assess costs and other barriers to waste transport.

Our study contributes to the limited body of literature on circular economy in the construction sector in three ways. Firstly, our research highlights the need to understand the context (geography and socio-technical systems) and to suggest solutions that address the context-based challenges rather than generalized urban solutions that rely on economies of scale. Secondly, it makes a theoretical contribution by extending the sustainable transitions literature to include the importance of context when using the framework. Thirdly, the practical contribution of this research is providing insights for focused interventions in regional areas for increasing adoption of circular economy.

## 2. Socio-technical system of construction waste

The sustainable transition studies address ways in which society needs to change to respond to current environmental problems, such as climate change, resource problems or biodiversity loss (Köhler et al. 2019). The shifts to address the above-mentioned environmental problems are called socio-technical transitions. Geels (2018, 2019) explains that the socio-technical transition approach is oriented towards understanding change processes as multi-actor, long-term goal-oriented, disruptive, contested and non-linear. The three interrelated dimensions in socio-technical transitions are as follows: the socio-technical systems, the human actors (can include organizations and social groups) and the rules (and institutions) (Geels 2004). In order to understand ways of transitioning to a more sustainable pathway, one needs to study the interactions between the systems, rules and the actors (see Figure 1).

The socio-technical system in this instance is the construction waste, made of materials. The technical in the socio-technical system refers to the 'construction technologies' that are used to build. This includes the materials used for a particular construction technology (bricks in load bearing construction or steel used in framed construction). The costs associated with each technology constrain or enable action.

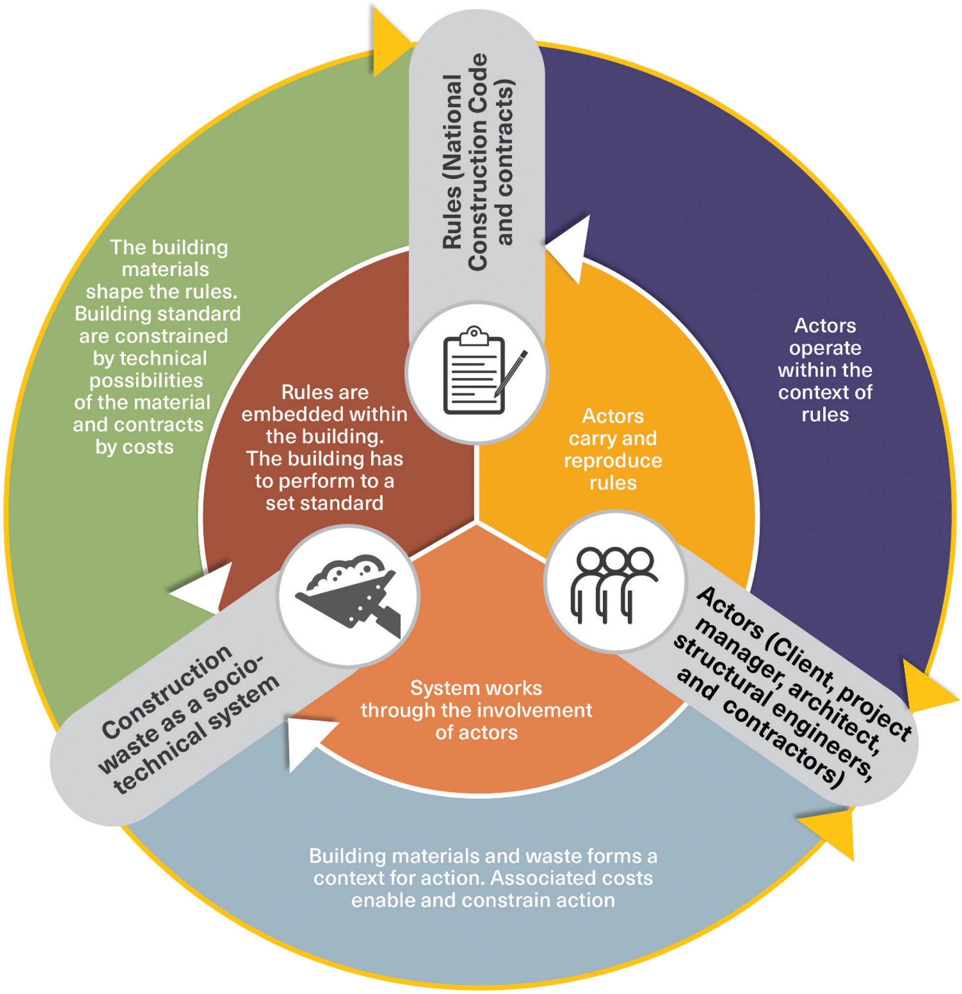


**Figure 1.** Conceptual dimensions of socio-technical transition in construction waste.
Source: Modified from Geels (2004).

This is particularly relevant since buildings are made of various materials and the choice of materials and construction technologies impact cost of the project.

The client/developer, architect, project manager, structural engineer and contractors are the primary actors that are 'viewed as the essential sources and forces of social changes' (Geels 2004, 906). The actors work within the boundaries of rules that provide constraining and enabling context. In the case of a building, the actors are bound by the National Construction Code (NCC). The NCC sets out the requirements for the design and construction of a building in Australia, including the use of materials, design choices and construction technologies used (Australian Building Codes Board n.d.). All building design and construction is required to comply with the NCC of Australia.

In addition, each stakeholder has to deliver on contracts and subcontracts they have agreed to in a project defining their roles and responsibilities. For example, the architect's role is to provide architectural design from the brief that the client provides, and the building contractor is bound by the rules laid out in the contract to build as per the drawings and specifications. The rules are there to ensure that the socio-technical system works. Such rules are not just shared by the actors but also embedded in artefacts, such as buildings.

While the socio-technical transitions approach provides an analytical tool for understanding the relationship between the three conceptual dimensions of the actors, the building as a system and the rules that govern, it does not provide any information on the geographical context that the building is set in. The limited understanding of spatially uneven and context-specific factors that enable such transitions has been identified as a limitation of sustainable transitions (Raven, Schot, and Berkhout 2012). In order to obtain a better understanding of how the context, in this instance the geography of regional towns, impacts transition towards a circular economy, we look at literature from geography on waste studies. It is critical to highlight that for any sustainable transition to circular economy, waste needs to be moved from place to place for its constituent parts to be 'deconstructed, reconstructed and transformed' which coined the term 'waste mobility' (Davies 2012, 191). Waste mobility consists of three interrelated themes needed to understand movement of waste: mapping flows, following things and waste immobilities. Mapping flows is concerned with ways the physical and political trajectories of waste are interconnected, highlighting the relationship between waste trade and regulations. Following things is about movement of organic and inorganic waste, and ways that material will be treated once it is not useful at the construction site. Waste immobility is the defining characteristic of waste that remains in particular places in a particular state, for differing periods of time. Examining waste through these three lenses will reveal the specific geographic barriers faced by regional towns towards transitioning to a circular economy.

## 3. Methodology: a case study approach

As identified earlier, lack of evidence from projects transiting towards a circular economy is a barrier in the adoption of circular economy practices in the construction sector. A case study approach was seen as appropriate since the project was an empirical inquiry investigating 'a contemporary phenomenon in depth and within its real-life context' (Yin 2009, 18). Unlike quantitative research, where statistical generalization is a key aim, this case study research focussed on providing rich, contextualized insights that are transferable and can be applied to similar contexts. Sourcing a case study building in the remote regional town of Alice Springs, before the tender stage, took time as new building projects become known to the public only after the tender is released for design, or even later if it follows an invited tender process. Therefore, the selected case study became known to the researchers only after the project was commissioned to the architects and the design process had started.

### 3.1. *The context: the regional town of Alice Springs in Australia*

Data for this study were gathered in Alice Springs, a small regional town located in Australia's Northern Territory (see Figure 2). The town is home to 25,912 people (ABS 2021). The Stuart Highway and the Darwin–Adelaide Railway are the two major connectors for bringing freight into the town, with only the road network used to carry any recyclables out to processing centres such as Adelaide.


**Figure 2.** Stuart Highway connecting Alice Springs to Adelaide and Darwin.
Source: Authors.

Alice Springs Town Council is responsible for managing the waste in the town and runs the Regional Waste Management Facility (RWMF). Domestic waste is collected by the council trucks but all commercial waste, which includes waste from construction sites, is delivered to the RWMF directly by the contractors. The rates for depositing waste vary with the waste stream as well as on waste separation. For example, $165 per tonne is charged for a load of mixed construction and demolition waste but when the concrete is separated, only $146 per tonne is charged and any clean fill (clean earth when digging foundations) is free for depositing (Alice Springs Town Council 2023). Objects, such as doors, windows or unbroken tiles, can be deposited free of charge at the Tip Shop at the RWMF, from where they are sold on.

The RWMF also accepts recyclables, namely paper and cardboard, metals, glass bottles, cans and concrete. Except for concrete and glass, the other materials are baled and sent out to Adelaide for reprocessing. Concrete is crushed and used in local projects and glass is crushed and sold locally. There are also two recyclers in town, who accept certain waste streams and then send them for reprocessing to Adelaide via trucks.

**Figure 3.** Reused aluminium partitions.
Source: Authors.

**Figure 4.** Careful dismantling of aluminium frames.
Source: Authors.

While the local government plays an integral role in the delivery of waste and recycling services, it is the responsibility of the state and territory government to regulate waste and manage waste through legislation, policies and programs in their jurisdictions. The Northern Territory's roadmap for transitioning towards circularity aims to establish the circular economy as an industry in the region (Northern Territory Government 2022).

Since circular economy is seen as an industry, it is important to understand the industrial landscape of Alice Springs, broadly indicated by the type and size of construction businesses. Businesses in the Northern Territory and in Alice Springs are predominantly small to medium sized. The largest percentage of employment (57%) in the construction industry is of non-employing businesses (sole traders), with the next highest (37%) businesses employing 1–19 people and a very small percentage (6%)

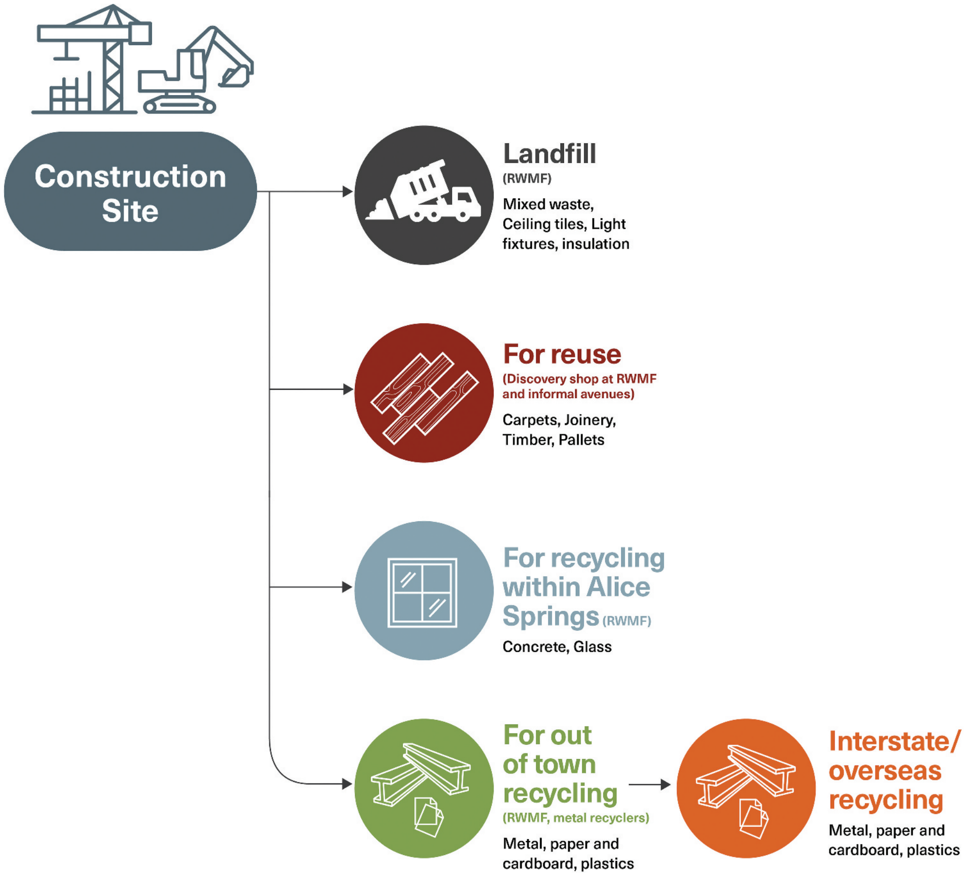


**Figure 5.** Movement of construction waste streams.
Source: Authors.

employing between 20 and 199 people (ISACNT, n.d). The workforce predominantly has certificate lll qualification (56%) with a quarter of the employees with no qualification (24%) (ISACNT, n.d). Any initiative for implementing a circular economy in construction would mean engaging with these small- and medium-sized businesses. There is a dearth of local manufacturing; therefore, building materials are generally freighted into remote regions. This is not surprising since 25–30% of construction materials are imported into Australia nationwide (ISACNT, n.d.; Robertson 2018). Increasing circularity in the NT would imply increasing manufacturing capability so that waste materials are reprocessed into new materials.

### 3.2. *The construction project: a renovation project at the Charles Darwin University*

The chosen case study is a renovation project of the student services and information area at the regional campus of Charles Darwin University in Alice Springs. The proposed works were to refurbish the ground floor of the administration building so that it presents a more welcoming environment for students and visitors to the campus. The university agreed to use circular economy principles in the design and construction of the project as long as it did not impact their already locked-in budgets. This is further discussed in Sections 4.4 and 5.1. Through the intervention, the clients of Charles Darwin University agreed to include a weightage for waste management in their tenders for building contractors. The building contractors were to respond to the call for tender by providing details of ways they would address the waste arising from the project. The selected contractor responded to the tender with the knowledge that having sustainable waste practices and diverting waste from landfill was one of the commitments they were making.

### 3.3. *Data collection*

Information from multiple sources of evidence (documents, interviews, site visits) was collected to construct validity and trustworthiness in the qualitative research project. Rules and regulations that the actors needed to abide by (such as National Building Code, national waste policies, building contracts) were examined for their influences on the process. The material flow during the construction and renovation was documented through site visits to understand this in the context of a regional town.

Approval for conducting interviews was obtained from the Charles Darwin University Human Research Ethics Committee (H22014). Interviews were recorded with approval of the interviewees for ease of transcription. Interviews were held with the primary actors in this renovation project and others associated with waste such as the client, Charles Darwin University (responsible for commissioning and managing the project); the Architecture firm of Susan Dugdale Associates (responsible for architectural design of the project); the building contractors, Scope Builders, (responsible for construction and demolition); The Recyclers, Antons Recycling and Alice Springs Metal Recyclers (accept certain waste streams generated at the construction site); the subcontractor Neeta Glass (glaziers responsible for fabricating partitions in the renovation project); and the Regional Waste Management Facility (RMWF) at Alice Springs (responsible for collecting, setting guidelines and fees for disposing waste at the local landfill).

Interviews were held with six primary stakeholders in the renovation project. Due to the exploratory nature of this research, sample sizes were not calculated using probability statistics. The interviewees were chosen through *maximal variation sampling*, a purposive sampling strategy, that allows data collection from a deliberately selected diverse range of individuals to capture a wide variety of perspectives and experiences related to the research question (Creswell and Clark 2017, 176). In this instance, the interviewees were the various actors holding different roles in the construction of the project and management of waste generated. This diverse group provided a complex picture of the phenomenon of construction practices and participation in a circular economy in the town. Participant selection bias was reduced by interviewing all the actors directly connected to the renovation project and not selecting a few actors. The semi-structured interview questions were aimed at generating insights into the current waste management practices, challenges and potential solutions associated with reducing construction and demolition waste. There was flexibility to ask additional questions during the interviews to clarify and further expand on certain issues.

In this instance, interviews were held with the primary actors who were involved in the design and construction of this project or received waste generated through this project. The interviews were held to gather in-depth information from this case study so as to gather insights into decision making on circularity in a particular building project. As a result, any other stakeholder groups not directly connected to the project were not interviewed.

### 3.4. *Data analysis*

This study applied an inductive qualitative thematic analysis approach. Data from the interviews was imported into the research analysis software program NVIVO. All interviews were analysed and coded to identify emerging themes and illustrative quotes were selected relating to key themes. Using the theoretical approach of socio-technical transitions helped construct internal and external validity to overcome the subjective nature of qualitative research. Process coding or 'action coding' was adopted as the initial coding to examine 'routines and rituals' followed by the actors (Saldaña 2021, 111). The first cycle codes were examined and reinterpreted to develop groupings and higher-level interpretations. Feedback loops ensured revision of codes, accuracy and trustworthiness within the process as well as challenging any pre-conceptions of researchers (Charmaz 2014). Memo writing while coding and during analysis captured codes and ideas which stood out.

The renovation project took 4 months to complete. To increase the reliability of the results, at the end of the project, a meeting was held with the three key stakeholders (client/project manager, architects and builders) to check the validity of the results. They agreed that the barriers discussed in section 5 were the primary deterrents to adoption of a circular economy in Alice Springs.

## 4. Results: the socio-technical system of the renovation project

The case study project was considered a socio-technical system built of materials, involving several actors, with each actor having a responsibility and a role to play in the project.

### 4.1. *Actors and their roles in waste management*

The Property and Facilities team within the Charles Darwin University were the project managers and the clients in this instance. Within the organization, this team provides space planning, oversight of new building design and construction, renovation, repair and other space management aspects. Commissioning and project managing the renovation project were their responsibility.

The architect's role was to design the space in line with design brief provided to them by the clients for renovation of the front information area. The architecture practice undertaking this renovation project is an established practice, working in Alice Springs since 2000. Their staff number ranges from 6 to 10 people. The practice scope ranges from architectural design and documentation to project management, master planning and interior design. The senior architect within the organization described their role as meeting the 'functional needs of the client' and 'to do something that is reasonably economic'. The National Construction Code (NCC) guiding architects' practices has no guidelines to promote circular economy practices within the building industry. There are green building rating systems such as Green Star and Nabers but there is a significant cost associated with these certifications.

The building contractors are a well-established commercial construction company in Alice Springs for over 20 years. The company's website advertises their ability to provide cost-effective solutions and timely delivery of projects. The architect and the builder stated that meeting the clients' requirements was their primary role. Since the NCC does not state including circularity in either design or construction, it is not a priority for either the architect or the builder.

## 4.2. *Actions taken by the actors towards reducing waste to landfill*

Introducing the awareness about waste management in a small project provided the clients, architects and the builders an opportunity to trial reducing waste on a small scale. The overheads of the architects, in terms of time, were paid through the research funding. This made the intervention more doable since no costs were added to the clients' budget.

### 4.2.1. *The client's initiative: participation in a waste reduction project*

Both the architect and the builder agreed that the client needs to be interested in sustainable practices for a project reducing waste to be successful and that the leadership should come from the client. The builder explained that the clients have the final say,

> The client has got to drive it at the end of the day and say we're in the business of constructing for our client. If our client is specifying something or wants something, we can certainly suggest alternative operations but you know, if they want it, that's what we're going to do for them. We are in the game to be responsible and reuse materials and recycle and do whatever we can and manage the waste. (Staff, Builder's organization)

The clients agreed that reducing waste requires an early intervention,

> It needs to start at the design phase and then it feeds into the construction phase because once you've documented it in the design phase, then it becomes a matter of course for the builder to execute what's been articulated in the design documents. (Staff, Client's organization)

Since the project was initiated after the initial design but before the tender for construction was released, there was more emphasis on reducing waste during the construction process. The clients described their initiative as identifying reducing waste in the tender documents and then evaluating the tenders for their commitment to waste reduction.

#### 4.2.2. *Design intervention by the architects*

In consultation with the clients, there were three major material reuse recommendations made by the architects for reducing waste. The first was reusing the existing aluminum partitions in the front office in the new refurbished space, in consultation with the glaziers. The architects measured the existing partitions and designed the new partitions so that the old partitions could be reused and no new materials were used for partition in that area (Figures 3 and 4).

The glazier explained the interaction with the architect as,

> ... asked me how we could reuse. So I had a look at the drawings, had a look at the existing windows and yeah, I could see that it was going to be quite a simple process. So we cut a fair bit of the old glass and reused doors where we could, etc., etc. And the glass and the doors was all reused. We didn't use any new product whatsoever. (Glazier)

The second material specified for reuse was timber panelling in the board room. The room had panelling on all walls and as part of refurbishment, most of the panelling was to be removed, leaving only small sections as a design feature. The drawing specified that the removed timber needed to be reused. None of the excess timber panelling was sent to the landfill. It was all taken by the construction site staff for personal reuse. The third material specified to be retained, was the suspended ceiling gridwork. The ceiling tiles were of a dark colour and were to be replaced with lighter colour tiles. The old ceiling tiles were carefully removed without damaging the metal frame. The new ceiling tiles were later inserted back into the frame.

Using recycled materials in a refurbishment contains certain challenges such as social acceptance of materials. In this instance, the old joinery was removed because it '*just doesn't meet current expectations*' (Staff, Architect's organization). The builders explained that a new look is often more important for organizations to commission a renovation than the costs. Using old materials also limits the options for the architects who are aiming for a particular design aesthetic. It was evident that since the client funds the project, they approve the final aesthetic and material selection.

#### 4.2.3. *Actions by the building contractor: treatment of materials arising from construction and demolition*

Construction and demolition materials arising from the refurbishing project were dealt-in with few ways. Since careful disposal of waste was a criterion in the tender, the building contractor demolished and sorted the waste arising from the demolition more carefully than what they might have otherwise done. This meant extra time was taken by the site staff for carrying out both demolition and sorting.

Sorting waste on site is an important step in material recovery. While time-consuming and requiring space on site for stockpiled materials, any unsorted materials more often than not result in landfill. Once mixed waste is put in a skip bin, recovery is virtually impossible. As the RWMF manager explains,

> We were happy to accept everything, you know, but if you've separated it, brilliant, we can do something more with it but if you throw it in the bin, goodbye. (Staff, RWMF)

The waste sorted on-site was either reused in the project; taken by the building contractor's staff for personal reuse; sent to one of the metal recyclers in town; sent to the Tip shop at the RWMF for selling or sent to the RWMF as mixed construction waste. The builders took certain materials to the Tip shop they would have otherwise put in mixed C&D waste and paid the landfill fee. The separated materials included carpets, doors and concrete blocks. The disposal fee was also saved on aluminium frames with glazing, timber panelling and aluminium ceiling grid frame as they were reused.

### 4.3. *Rules followed by the actors: tenders, contract and the national construction code*

The architect and the builder were employed on this project through a tendering process. The tenders were evaluated on the applicant's capacity, previous performance, proposed methodology and the fees charged. The Request for Quote (RFQ) for architecture practices did not mention waste reduction as an evaluation criterion since the architects were selected before the research project was started. Most architecture practices prepare an initial sketch design, for approval with the clients and a detailed set of drawings once the sketch design is approved. Since the initiative to reduce waste was introduced after the sketch design stage, the changes to reduce waste were only done at the detailed design stage. At this point, the architecture practice examined the design in detail and specified materials that could be reused.

After the detailed drawings were prepared, the client then issued a RFQ to a panel of building contractors and the successful builder entered into a contract with the client. The evaluation criteria for selecting the building contractor were similar to those for the architects with the additional requirement (weighted 10%) for sustainable practices. The sustainability section in the response schedule specifically asked the tenderers to detail 'strategies proposed for this project that will minimize waste to landfill and increase recycling rates and proposed reporting mechanisms' (Client's tender document).

The selected building contractor said that their organization quoted the price for the tender based on the tender drawings and specifications provided to them. They added that in their earlier projects, even if responsible waste management was stipulated, it was rare for clients to check for compliance. Since waste planning was a prerequisite for this project, the builders provided the clients with receipts of disposing waste at the RWMF or recyclers.

As per the contract drawings, the building contractors adhered to retaining and reusing certain materials', such as the aluminum glass partitions. At the start, the builders said that their waste management practices in this project were similar to what they would do on other construction sites. However, later they did admit to several practices of sorting and disposing waste that were very particular to this project. They attributed this to the project's focus on waste reduction and the inclusion of this in their contracts. For example, reusing partitions was an unusual practice that they were asked to carry out. The builder described,

> It's very rare that we would reuse like the aluminium frames on a job site. Yes, we would recycle them when we demolish them but it's pretty rare that we would demolish them and then rebuild the new partitions using the existing stuff and going again. Often it is just stripped out and get rid of it and put new stuff in. (Staff, Builder's organization)

The inclusion of waste management as a sustainability criterion in the tender led to reusing partitions, ceiling tile frames, timber paneling and other materials. It made the actors more aware of ways they could divert building materials from landfill. However, several window glass and door hardware used in the old construction did not meet the new Australian safety standards and were not reused.

### 4.4. *Socio-technical system of buildings: materials and associated costs*

Economic costs influenced all aspects of the project. There is a cost associated with researching new ways of reducing waste through design, since this will require staff to spend additional time. Therefore, if this is not factored in at the beginning of the project, the architect is reluctant to spend that additional time and the client is less inclined to pay for it once the project has started. The architects' extra time on finding ways to reduce waste in this instance was paid through the grant. The architects observed,

> So there's definitely additional time required and so that needs to be built into our fee to allow time, extra time for that level of design to reuse things. We need to know a lot more detail about the existing conditions if we want to reuse something. So yeah, if it's not written into our starting brief that we put a fee to then it's, we're less motivated to do it, unless it's regarded as a variation or some way of recognising the work. (Staff, Architect's organization)

As observed in this project, there are additional costs for architects' time that a client needs to be aware of when preparing the brief for including circularity in building construction.

For the builder running a construction business, waste reduction comes down to whether it is either cost neutral or profitable. The builder explained that as a business, their mandate is to make a profit. However, with waste disposal, they are not looking to make a profit but rather break even.

For example, the metal recyclers accept ferrous metal free of charge and pay the builder for the non-ferrous metals, whereas the RWMF charges them per tonne of metal deposited. Hence, it is more cost-effective to separate metal from other demolition waste and take it to the metal recycler. The builder explained,

> If we can recycle it and you know, it's not so much about making a dollar from it but being cost neutral, so if we can get the metal to the metal recyclers and it doesn't cost us anything instead of, you know, $350 a tonne or whatever it costs us to take it to the tip, that's where it comes down to. It's a dollar value for us. (Staff, Builder's organization)

Similarly, there is a cost when demolishing carefully for reusing materials or sorting for sending to recycling. The quickest way would be to demolish and put it all in a pile or in the skip as mixed waste. As described by the builder,

> Obviously we're going to take a lot more care if we're going to pull something out and reuse it rather than just ripping it out and bashing it to pieces, a ten-minute job versus an hours' job. (Staff, Builder's organization)

The trade-off for the builders is the difference between landfill fees for disposing mixed waste and disposing sorted waste. The builders explained that they pay a higher fee at the landfill if they take in mixed waste. It was cheaper for them to separate at site and then take different wastes to the landfill, either layered in their trucks or to make separate trips to the landfill with one material.

### 4.5. *Mapping flows, following things and waste immobilities*

#### 4.5.1. *Markets for materials in a small town*

Even if the materials are sorted and sent to the RWMF, there are limitations for reusing and recycling construction waste. All products that can be sold are diverted from the landfill and sent to the Tip shop. The remaining, concrete and glass are crushed and reused in the local council's projects and metal is sent to metal recyclers and reusable carpets are sent to the Tip shop.

As the RWMF manager explained, the aim is diverting waste from landfill and not making profit from selling materials. He gave the example, that if a clean carpet is brought from a construction site, it can be sold at the Tip shop rather than put in the landfill as mixed demolition waste. The client also highlighted that commercial gains from recycling will only occur when there is a market for recyclables.

#### 4.5.2. *Movement of materials for reprocessing*

The baled cardboard at the RWMF and the metal collected by the metal recycler is sent to Adelaide for recycling due to lack of recycling facilities in Alice Springs. Figure 5 shows the movement of different waste materials.

The metal recycler accepts ferrous metals (iron and steel in pipes, cisterns, fittings) for free and pays the builders for the non-ferrous (aluminium, copper, lead and tin) metals they bring. The recycler explained the pricing of their structure:

> We have to pay truck companies to send our metal down to Adelaide so that's why we have to juggle how much we're going to get per tonne for that load and how much we pay the truck driver for that freight. It gets paid per tonne. (Staff, Recycler)

The recyclers using trucks for backloading metal when sending it to Adelaide complained that sourcing trucks for backloading can be erratic.

The glazier explained that not all glass can be recycled. The RWMF can't crush safety glass, and the glaziers and the builders have to pay when taking it to the RWMF. It is expensive for the RWMF to send the safety glass and the coloured glass to interstate recyclers due to high freight costs. The glazier explained,

> It's a difficult one with the freight cost because they're (glass recyclers) going to give you nothing for it and the freight costs are going to be very expensive. Glass can't be transported like anything else, it's either got to be broken and put into large steel bins or it has to go on A-frames and be carried on edge. So it's a difficult process. (Staff, Recycler)

The fluctuating commodity market too influence the movement of recyclables. The recyclers stockpile materials when the commodity prices are low and send them for recycling when they are high.

## 5. Discussion

In the first place, the themes emerging from the data revealed the roles of various actors in waste management, the actions they took towards diverting waste, the regulations guiding them and the costs associated with their design and material choices. Next, examining the waste movement showed the limited markets and long transport distances for reprocessing materials. The overarching links between the various themes were as follows: the importance of a client in implementing a circular economy; impact of small- and medium-sized businesses in regional contexts; and the high cost of transporting waste materials. These findings are discussed in detail below.

### 5.1. *Role of clients*

The results show that clients commissioning a construction project play a critical role in decision-making for participating in a circular economy. The importance of the role of the client is an interesting result, since most studies examining circular economy in the construction sector discuss awareness and behaviour of different stakeholders in general (Gerding, Wamelink, and Leclercq 2021) although some have discussed the role of managers (Teo and Loosemore 2001) and of clients (Shooshtarian et al. 2022). In this research project, the clients showed leadership by adopting a circular economy approach and thereby asking architects to reuse certain materials and by including a weightage for waste management in their tender documents. Since the client appoints the architect, project manager, builder and any other consultant, their acceptance of a circular economy practice in building construction projects is critical to the adoption of circularity aspects. The results also showed that the client did not want to pay extra for including any circular economy initiatives. They agreed to participate on the condition that they would bear no additional costs. This shows the competing priorities for a client between sustainability and budget constraints.

This finding resonates with research by Gerding, Wamelink, and Leclercq (2021) that the biggest impacts for circular economy are achieved by interventions made by actors early in a project's life. Early interventions can make green choices easier, more attractive, affordable and normal. Zhao (2021) has also identified that the awareness and attitude of clients or developers significantly influence designers, contractors and sub-contractors for construction and demolition waste management. Similarly, Osmani, Glass, and Price (2006) have found that lack of client interest is a major barrier to waste management practices.

This finding is important since it clearly demonstrates that a circular economy approach will work best in a construction project, firstly if it is a criterion right from the start and secondly, that incentives and awareness programs need to be targeted at the clients, project managers and developers who are in charge of commissioning, managing or drawing up contracts in a construction project. To increase chances of successful integration of a circular economy in construction projects, it is more important for actors in leadership roles to create conditions for a circular economy to occur rather than only relying on technological solutions of recycling.

### 5.2. *Regional context and SMEs*

The results also showed that a technological solution without understanding the regional context will not work successfully in regional towns which predominantly have small and medium size businesses. The small sizes of businesses (architects, builders and sub-contractors) faced the barrier of lack of knowledge about how to reduce and manage waste. These actors had to spend extra time (and therefore additional economic costs) in finding out ways to reduce waste from construction and demolition activities. Since they are small businesses, with limited staff, they have less resources to invest in research and untested solutions. Therefore, although they were interested in better environmental solutions, their primary interest was ensuring they did not suffer a loss by spending time in acquiring new knowledge or implementing new solutions.

These results are supported by Rizos et al. (2015) who have reported upfront investment costs and lack of knowledge about the circular economy as barriers faced by small and medium organizations. García-Quevedo, Jové-Llopis, and Martínez-Ros (2020) identify firm size as barrier to SME's participating in circular economy activities. Literature also indicates that SMEs focus their investment decisions on direct returns and benefits from core business and the risk of shortage of resources is a big barrier for them (Dex and Scheibl 2001; Takacs, Brunner, and Frankenberger 2022). For SMEs to participate, the client's commitment to CE was important since this was then reflected in their contracts and economic arrangements. This indicates that there is a need to equip SMEs who are actors in the construction system, with knowledge and training about viable circular economy solutions in regional towns. This can be done through peak body organizations such as the Institute of Architects and Master Builders through their professional development programs.

### 5.3. *Cost of transporting waste from regional towns*

Further, our research showed that most decisions for reducing waste were based on economic viability. While this is not a new finding since several studies have highlighted economic barriers as significant in implementing circular economy (Purchase et al. 2021; Ratnasabapathy, Alashwal, and Perera 2021). Our research outlined the additional tyranny of distance that regional towns need to navigate. As was evident from the results, the transport costs to reprocessing centres from regional towns are higher. This is then reflected in material collection options offered by the recyclers and the RWMF. Not all materials are economically viable for sending interstate for recycling after adding transport costs and working out reverse logistics.

Due to this, each material arising from the activity of demolition and construction follows a different trajectory from the construction site. The factors that played a role in how each material was disposed were as follows: availability of a place to dispose (such as the RWMF or the recycler), the cost of disposal and the returns for the material. For example, neither the RWMF nor the recyclers collect plastic offcuts. These are not separated on site but put in mixed waste. There is no economic benefit for the RWMF or the recycler to collect and send plastics for reprocessing. Metal is, however, accepted free of charge by the metal recyclers. It costs the contractors high fees if they send it to the RWMF. All metals are, therefore, separated and taken to the metal recyclers. The metal recyclers then send it to Adelaide for reprocessing since they get enough economic returns.

This result is supported by Guzdek et al. (2020)'s study which states that the cost of transporting waste is one of the most important elements of waste management and that waste should be treated or disposed of as near to its place of origin. This then leads to the question of who should pay for the transport costs. da Cruz, Simões, and Marques (2012) examined the role of the material producer (for example, the packaging industry) and their responsibility in bearing costs associated with transport and processing after the material has been collected by the local authorities. Material flow analysis of construction materials has highlighted the difficulty of closing the loop, due to which large amounts of various materials are put in landfill (Huang and Hsu 2003). It also needs to be noted that while the environmental impacts of transporting waste have been discussed extensively (Ghisellini, Ripa, and Ulgiati 2018; Martínez, Nuñez, and Sobaberas 2013; Vitale et al. 2017), there is a dearth of studies examining economic costs of waste movement.

## 6. Conclusion

This study aimed to identify the barriers to implementing a circular economy in regional Australian towns by examining a refurbishment project set in Alice Springs, from the design phase to completion. We examined the building construction waste as a socio-technical system, the role of various stakeholders involved in the system, the rules they are required to follow and the transport of waste. By highlighting the importance of including spatial considerations in the socio-technical transition literature, this study makes a substantial empirical and theoretical contribution to the existing literature. The analysis, framed through the three interconnected dimensions of the socio-technical system and waste mobilities, highlighted the critical role of clients in initiating circular economy practices in a construction project. It also underscored the challenges faced by small businesses in regional towns, in particular resource and staff limitations. Additionally, the long distances between regional towns to reprocessing centres emerged as a significant barrier for collecting, transporting and recycling various construction materials.

The results further reveal some important policy implications. For circular economy practices to be more widely adopted in construction sector in spacey populated regional areas, clients should be incentivized to adopt circular economy practices without the concern of increased costs. Financial incentives, such as tax breaks or subsidies, could promote financially constrained small- and medium-sized businesses to incorporate circular economy principles into their projects. Specific environmental ratings for regional towns, transport subsidies and institutional support for upskilling building industry are important interventions that would help these regions to participate in a circular economy. Embedding circular economy criteria into procurement policies and providing clients with the necessary support and guidance to balance sustainability and budget constraints could further promote industry-wide implementation. Additionally, addressing the economic barriers to waste reduction and recycling in regional towns requires targeted strategies that account for the costs of transportation as well as the unique challenges posed by distance and that of businesses that operates at a smaller scale compared to large metropolitan areas. Such policies would not only ensure that recycling options are economically viable and accessible for regional towns but also promote regional economic sustainability and equity in access to circular economy benefits. One of the limitations of this study was not including policymakers and community groups as key stakeholders and obtaining their voice through interviews. Future research should include them to obtain more insights into circularity. This study also necessitates future research on how incentive schemes could look like and on mitigating knowledge and economic barriers to the adoption of circular economy practices.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

The work was supported by the Northern Territory Government's Environment Grant and the COVID Supplementary Funding Pool (CFSP) funds provided by the Charles Darwin University.

## References

Akanbi, L. A., L. O. Oyedele, O. O. Akinade, A. O. Ajayi, M. D. Delgado, M. Bilal, and S. A. Bello. 2018. "Salvaging Building Materials in a Circular Economy: A BIM-Based Whole-Life Performance Estimator." *Resources, Conservation and Recycling* 129:175–186. https://doi.org/10.1016/j.resconrec.2017.10.026.

Alice Springs Town Council. 2023. "Price List." Accessed March 20, 2024. https://assets-astc.s3-ap-southeast-2.amazonaws.com/files/2023-Price-List.pdf.

Antwi-Afari, P., S. T. Ng, J. Chen, B. I. Oluleye, M. F. Antwi-Afari, and B. K. Ababio. 2023. "Enhancing Life Cycle Assessment for Circular Economy Measurement of Different Case Scenarios of Modular Steel Slab." *Building and Environment* 239:110411. https://doi.org/10.1016/j.buildenv.2023.110411.

Australian Building Codes Board. n.d. "National Construction Code." https://ncc.abcb.gov.au/.

Australian Bureau of Statistics. 2021. "Alice Springs 2021 Census All Persons QuickStats." https://abs.gov.au/census/find-census-data/quickstats/2021/LGA70200.

Australian Government. 2019. "National Waste Policy: Action Plan." https://www.agriculture.gov.au/sites/default/files/documents/national-waste-policy-action-plan-2019.pdf.

Bao, Z., and W. Lu. 2020. "Developing Efficient Circularity for Construction and Demolition Waste Management in Fast Emerging Economies: Lessons Learned from Shenzhen, China." *Science of the Total Environment* 724:138264. https://doi.org/10.1016/j.scitotenv.2020.138264.

Bao, Z., W. Lu, B. Chi, J. Hao, P. Miao, X. Gao, Z. Zhao, and B. Cheng. 2019. "The Barriers and Strategies of Conducting On-Site Sorting of Construction Waste: A Case Study of Suzhou." International Symposium on Advancement of Construction Management and Real Estate, Chongqing, China, 29 November - 2 December.

Barakat, B., and I. Srour. 2024. "A Multi-Stakeholder Digital Platform for Regional Construction and Demolition Waste Management." *Waste Management & Research* 42 (2): 178–188. https://doi.org/10.1177/0734242X231175818.

Benton, D., J. Hazell, and J. Hill. 2017. *The Guide to the Circular Economy: Capturing Value and Managing Material Risk*. London: Routledge.

Bilal, M., K. I. A. Khan, M. J. Thaheem, and A. R. Nasir. 2020. "Current State and Barriers to the Circular Economy in the Building Sector: Towards a Mitigation Framework." *Journal of Cleaner Production* 276:123250. https://doi.org/10.1016/j.jclepro.2020.123250.

Blattner, C. 2020. "Just Transition for Agriculture? A Critical Step in Tackling Climate Change." *Journal of Agriculture, Food, Systems, and Community Development* 9 (3): 53–58. https://doi.org/10.5304/jafscd.2020.093.006.

Brambilla, G., M. Lavagna, G. Vasdravellis, and C. A. Castiglioni. 2019. “Environmental Benefits Arising from Demountable Steel-Concrete Composite Floor Systems in Buildings.” *Resources, Conservation and Recycling* 141:133–142. https://doi.org/10.1016/j.resconrec.2018.10.014.
Campbell-Johnston, K., J. ten Cate, M. Elfering-Petrovic, and J. Gupta. 2019. “City Level Circular Transitions: Barriers and Limits in Amsterdam, Utrecht and the Hague.” *Journal of Cleaner Production* 235:1232–1239. https://doi.org/10.1016/j.jclepro.2019.06.106.
Campbell-Johnston, K., W. J. Vermeulen, D. Reike, and S. Brullot. 2020. “The Circular Economy and Cascading: Towards a Framework.” *Resources, Conservation & Recycling: X* 7:100038. https://doi.org/10.1016/j.rcrx.2020.100038.
Charef, R., and S. Emmitt. 2021. “Uses of Building Information Modelling for Overcoming Barriers to a Circular Economy.” *Journal of Cleaner Production* 285:124854. https://doi.org/10.1016/j.jclepro.2020.124854.
Charef, R., and W. Lu. 2021. “Factor Dynamics to Facilitate Circular Economy Adoption in Construction.” *Journal of Cleaner Production* 319:128639. https://doi.org/10.1016/j.jclepro.2021.128639.
Charef, R., W. Lu, and D. Hall. 2022. “The Transition to the Circular Economy of the Construction Industry: Insights into Sustainable Approaches to Improve the Understanding.” *Journal of Cleaner Production* 364:132421. https://doi.org/10.1016/j.jclepro.2022.132421.
Charmaz, K. 2014. *Constructing Grounded Theory*. London, UK: Sage publications.
Creswell, J. W., and V. L. P. Clark. 2017. *Designing and Conducting Mixed Methods Research*. Thousand Oaks, CA: Sage publications.
Cruz Rios, F., S. Panic, D. Grau, V. Khanna, J. Zapitelli, and M. Bilec. 2022. “Exploring Circular Economies in the Built Environment from a Complex Systems Perspective: A Systematic Review and Conceptual Model at the City Scale.” *Sustainable Cities and Society* 80:103411. https://doi.org/10.1016/j.scs.2021.103411.
da Cruz, N. F., P. Simões, and R. C. Marques. 2012. “Economic Cost Recovery in the Recycling of Packaging Waste: The Case of Portugal.” *Journal of Cleaner Production* 37:8–18. https://doi.org/10.1016/j.jclepro.2012.05.043.
Davies, A. R. 2012. “Geography and the Matter of Waste Mobilities.” *Transactions of the Institute of British Geographers* 37 (2): 191–196. https://doi.org/10.1111/j.1475-5661.2011.00472.x.
Dex, S., and F. Scheibl. 2001. “Flexible and Family-Friendly Working Arrangements in UK-Based SMEs: Business Cases.” *British Journal of Industrial Relations* 39 (3): 411–431. https://doi.org/10.1111/1467-8543.00207.
Ding, S., W. Huang, W. Xu, Y. Wu, Y. Zhao, P. Fang, B. Hu, and L. Lou. 2022. “Improving Kitchen Waste Composting Maturity by Optimizing the Processing Parameters Based on Machine Learning Model.” *Bioresource Technology* 360:127606. https://doi.org/10.1016/j.biortech.2022.127606.
Ding, Z., Y. Wang, and P. X. W. Zou. 2016. “An Agent Based Environmental Impact Assessment of Building Demolition Waste Management: Conventional versus Green Management [Article].” *Journal of Cleaner Production* 133:1136–1153. https://doi.org/10.1016/j.jclepro.2016.06.054.
Ellen MacArthur Foundation. 2017. “What is a Circular Economy?” https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview.
García-Quevedo, J., E. Jové-Llopis, and E. Martínez-Ros. 2020. “Barriers to the Circular Economy in European Small and Medium-Sized Firms.” *Business Strategy and the Environment* 29 (6): 2450–2464. https://doi.org/10.1002/bse.2513.
Geels, F. W. 2004. “From Sectoral Systems of Innovation to Socio-Technical Systems: Insights About Dynamics and Change from Sociology and Institutional Theory.” *Research Policy* 33 (6–7): 897–920. https://doi.org/10.1016/j.respol.2004.01.015.
Geels, F. W. 2018. “Socio-Technical Transitions to Sustainability.” In *Oxford Research Encyclopedia of Environmental Science*. Oxford, UK: Oxford University Press. https://doi.org/10.1093/acrefore/9780199389414.013.587.
Geels, F. W. 2019. “Socio-Technical Transitions to Sustainability: A Review of Criticisms and Elaborations of the Multi-Level Perspective.” *Current Opinion in Environmental Sustainability* 39:187–201. https://doi.org/10.1016/j.cosust.2019.06.009.

Gerding, D. P., H. Wamelink, and E. M. Leclercq. 2021. “Implementing Circularity in the Construction Process: A Case Study Examining the Reorganization of Multi-Actor Environment and the Decision-Making Process.” *Construction Management & Economics* 39 (7): 617–635. https://doi.org/10.1080/01446193.2021.1934885.

Ghisellini, P., M. Ripa, and S. Ulgiati. 2018. “Exploring Environmental and Economic Costs and Benefits of a Circular Economy Approach to the Construction and Demolition Sector. A Literature Review.” *Journal of Cleaner Production* 178:618–643. https://doi.org/10.1016/j.jclepro.2017.11.207.

Government of Western Australia. 2020. *Closing the Loop – Waste Reforms for a Circular Economy*. https://consult.dwer.wa.gov.au/waste-policy/consultation-dashboard-closing-the-loop/.

Green Industries SA. 2020. *Supporting the Circular Economy: South Australia’s Waste Strategy 2020–2025*. Adelaide. https://www.greenindustries.sa.gov.au/resources/sa-waste-strategy-2020-2025.

Guerra, B. C., and F. Leite. 2021. “Circular Economy in the Construction Industry: An Overview of United States stakeholders’ Awareness, Major Challenges, and Enablers.” *Resources, Conservation & Recycling* 170:105617.

Guzdek, S., M. Malinowski, A. Liszka, D. Religa, and A. Petryk. 2020. “Economic and Ecological Assessment of Transport of Various Types of Waste.” *Journal of Ecological Engineering* 21 (5): 19–26. https://doi.org/10.12911/22998993/122120.

Hart, J., K. Adams, J. Giesekam, D. D. Tingley, and F. Pomponi. 2019. “Barriers and Drivers in a Circular Economy: The Case of the Built Environment.” *Procedia Cirp* 80:619–624. https://doi.org/10.1016/j.procir.2018.12.015.

Huang, S.-L., and W.-L. Hsu. 2003. “Materials Flow Analysis and Emergy Evaluation of Taipei’s Urban Construction.” *Landscape and Urban Planning* 63 (2): 61–74. https://doi.org/10.1016/S0169-2046(02)00152-4.

ISACNT. n.d. “Northern territory’s Construction Industry.” Accessed May 8, 2024 https://www.isacnt.org.au/construction.

Jaeger-Erben, M., C. Jensen, F. Hofmann, and J. Zwiers. 2021. “There is No Sustainable Circular Economy without a Circular Society.” *Resources, Conservation and Recycling* 168 (5): 105476. https://doi.org/10.1016/j.resconrec.2021.105476.

Kirchherr, J., L. Piscicelli, R. Bour, E. Kostense-Smit, J. Muller, A. Huibrechtse-Truijens, and M. Hekkert. 2018. “Barriers to the Circular Economy: Evidence from the European Union (EU).” *Ecological Economics* 150:264–272. https://doi.org/10.1016/j.ecolecon.2018.04.028.

Köhler, J., F. W. Geels, F. Kern, J. Markard, E. Onsongo, A. Wieczorek, F. Alkemade, F. Avelino, A. Bergek, and F. Boons. 2019. “An Agenda for Sustainability Transitions Research: State of the Art and Future Directions.” *Environmental Innovation and Societal Transitions* 31:1–32. https://doi.org/10.1016/j.eist.2019.01.004.

Lieder, M., and A. Rashid. 2016. “Towards Circular Economy Implementation: A Comprehensive Review in Context of Manufacturing Industry.” *Journal of Cleaner Production* 115:36–51. https://doi.org/10.1016/j.jclepro.2015.12.042.

Martínez, E., Y. Nuñez, and E. Sobaberas. 2013. “End of Life of Buildings: Three Alternatives, Two Scenarios. A Case Study.” *The International Journal of Life Cycle Assessment* 18 (5): 1082–1088. https://doi.org/10.1007/s11367-013-0566-4.

Northern Territory Government. 2022. “Northern Territory Circular Economy Strategy 2022 - 2027.” https://depws.nt.gov.au/__data/assets/pdf_file/0020/1100882/northern-territory-circular-economy-strategy-2022-2027.pdf.

Osmani, M., J. Glass, and A. Price. 2006. “Architect and Contractor Attitudes to Waste Minimisation.” Proceedings of the Institution of Civil Engineers-Waste and Resource Management 159:2 65–72.

Park, J., and R. Tucker. 2017. “Overcoming Barriers to the Reuse of Construction Waste Material in Australia: A Review of the Literature.” *International Journal of Construction Management* 17 (3): 228–237. https://doi.org/10.1080/15623599.2016.1192248.

Purchase, C. K., D. M. Al Zulayq, B. T. O’Brien, M. J. Kowalewski, A. Berenjian, A. H. Tarighaleslami, and M. Seifan. 2021. “Circular Economy of Construction and

Demolition Waste: A Literature Review on Lessons, Challenges, and Benefits." *Materials* 15 (1): 76. https://doi.org/10.3390/ma15010076.

Ratnasabapathy, S., A. Alashwal, and S. Perera. 2021. "Exploring the Barriers for Implementing Waste Trading Practices in the Construction Industry in Australia." *Built Environment Project and Asset Management* 11 (4): 559–576. https://doi.org/10.1108/BEPAM-04-2020-0077.

Raven, R., J. Schot, and F. Berkhout. 2012. "Space and Scale in Socio-Technical Transitions." *Environmental Innovation and Societal Transitions* 4:63–78. https://doi.org/10.1016/j.eist.2012.08.001.

Ritzén, S., and G. Ö. Sandström. 2017. "Barriers to the Circular Economy–Integration of Perspectives and Domains." *Procedia Cirp* 64:7–12. https://doi.org/10.1016/j.procir.2017.03.005.

Rizos, V., A. Behrens, T. Kafyeke, M. Hirschnitz-Garbers, and A. Ioannou. 2015. "The Circular Economy: Barriers and Opportunities for SMEs." *CEPS Working Documents*.

Robertson, H. 2018. "Building in Ways That Meet the Needs of Australia's Remote Regions." *The Conversation*. https://theconversation.com/building-in-ways-that-meet-the-needs-of-australias-remote-regions-106071.

Saldaña, J. 2021. *The Coding Manual for Qualitative Researchers*. Los Angeles, CA: Sage Publications.

Salmenperä, H., K. Pitkänen, P. Kautto, and L. Saikku. 2021. "Critical Factors for Enhancing the Circular Economy in Waste Management." *Journal of Cleaner Production* 280:124339. https://doi.org/10.1016/j.jclepro.2020.124339.

Shooshtarian, S., S. Caldera, T. Maqsood, T. Ryley, P. S. Wong, and A. Zaman. 2022. "Analysis of Factors Influencing the Creation and Stimulation of the Australian Market for Recycled Construction and Demolition Waste Products." *Sustainable Production and Consumption* 34:163–176. https://doi.org/10.1016/j.spc.2022.09.005.

Shooshtarian, S., T. Maqsood, P. S. Wong, R. J. Yang, and M. Khalfan. 2020. "Review of Waste Strategy Documents in Australia: Analysis of Strategies for Construction and Demolition Waste." *International Journal of Environmental Technology and Management* 23 (1): 1–21. https://doi.org/10.1504/IJETM.2020.110147.

Soto-Paz, J., O. Arroyo, L. E. Torres-Guevara, B. A. Parra-Orobio, and M. Casallas-Ojeda. 2023. "The Circular Economy in the Construction and Demolition Waste Management: A Comparative Analysis in Emerging and Developed Countries." *Journal of Building Engineering* 78:107724. https://doi.org/10.1016/j.jobe.2023.107724.

Sovacool, B. K., and S. Griffiths. 2020. "The Cultural Barriers to a Low-Carbon Future: A Review of Six Mobility and Energy Transitions Across 28 Countries." *Renewable and Sustainable Energy Reviews* 119:109569. https://doi.org/10.1016/j.rser.2019.109569.

Takacs, F., D. Brunner, and K. Frankenberger. 2022. "Barriers to a Circular Economy in Small- and Medium-Sized Enterprises and Their Integration in a Sustainable Strategic Management Framework." *Journal of Cleaner Production* 362:132227. https://doi.org/10.1016/j.jclepro.2022.132227.

Teo, M. M. M., and M. Loosemore. 2001. "A Theory of Waste Behaviour in the Construction Industry [Article]." *Construction Management & Economics* 19 (7): 741–751. https://doi.org/10.1080/01446190110067037.

Urbinati, A., S. Franzò, and D. Chiaroni. 2021. "Enablers and Barriers for Circular Business Models: An Empirical Analysis in the Italian Automotive Industry." *Sustainable Production and Consumption* 27:551–566. https://doi.org/10.1016/j.spc.2021.01.022.

Vitale, P., N. Arena, F. Di Gregorio, and U. Arena. 2017. "Life Cycle Assessment of the End-of-Life Phase of a Residential Building." *Waste Management* 60:311–321. https://doi.org/10.1016/j.wasman.2016.10.002.

Yin, R. K. 2009. *Case Study Research: Design and Methods*. Vol. 5. Thousand Oaks, CA: Sage.

Zhao, X. 2021. "Stakeholder-Associated Factors Influencing Construction and Demolition Waste Management: A Systematic Review." *Buildings* 11 (4): 149. https://doi.org/10.3390/buildings11040149.