
Can bio-based building materials change the future of Brisbane's development industry and encourage a transition toward a circular city?



(Baldwin, 2019)

Morgan, F. Loic (7040601), L.f.morgan@students.uu.nl

Utrecht University of Applied Sciences, Faculty of Geosciences, The Netherlands

JAAR Master's thesis Spatial Planning (GEO4-3111)

June 2024



Table of Contents

Table of Contents	2
Acknowledgements.....	4
Abbreviations	5
Abstract.....	6
1.0 Introduction.....	7
1.1 Research Objective and Research Questions	9
2.0 Literature Review.....	10
2.1 Sustainability and Sustainable Development.....	10
2.2 The Three Pillars of Sustainability	12
2.3 Circular Economy in the Urban Context.....	13
2.4 Bio-Based Materials.....	15
3.0 Theoretical Framework.....	16
4.0 Methodology.....	18
4.1 Case Study Research.....	18
4.2 Semi-Structured Interviews.....	20
4.3 The Interview Process	21
4.4 Limitations of Research Methods.....	22
5.0 Results	23
5.1 Key Barriers of Bio-Based Building Materials in Brisbane's Development Industry.....	23
5.1.1 Cost	26
5.1.2 Materials and Supply	26
5.1.3 Politics and Governance.....	27
5.1.4 Time.....	27
5.1.5 Education.....	28
5.1.6 Risk and Uncertainty.....	28
5.2 Key Opportunities of Bio-Based Building Materials in Brisbane's Development Industry	28
5.2.1 Education and Awareness	32
5.2.2 Technological Advancements.....	32
5.2.3 Policy Implementation.....	34
5.2.4 Circular Economy and LCA	34
5.2.5 Certifications and Ratings.....	34
5.2.6 Production.....	35
5.3 Identified Stakeholders and their Role in this Sustainable Transition	36
6.0 Discussion	37

BRISBANE'S TRANSITION TO A CIRCULAR CITY

6.1	Synthesis of Research and Results.....	37
6.2	Response to the Research Questions	38
6.3	Planning Recommendations from Results.....	39
7.0	Conclusion.....	40
7.1	Summary of Study	40
7.2	Recommendations for Further Research.....	40
8.0	Bibliography.....	41
9.0	Appendices.....	45
	Appendix 1: Interview Guideline.....	45
	Figure 1: Evolution of population by degree of urbanisation 1950–2070 (UN Habitat, 2022, p.40)	8
	Figure 2: Progress Overview of SDG 11 & 13 (UN, 2023).....	11
	Figure 3: Three Pillars of Sustainability (Purvis et al, 2018)	12
	Figure 4: Current Signatories of the Circular Cities Declaration (CCD, 2024)	14
	Figure 5: Approved Mass Timber Tower in Perth, Australia (Tabet, 2022).....	15
	Figure 6: The Circular Economy Framework (Elia et al, 2017)	17
	Figure 7: Brisbane Statistical Local Government Area (Hipp et al. 2014).....	19
	Figure 8: Mass Timber Dwelling House in Suburban Brisbane (Morgan, 2024)	33
	Figure 9: The Monterey – First CLT High-Rise Residential Building in Brisbane (Morgan, 2024)	33
	Figure 10: Aurecon Office – First Mass Timber Commercial Building in Brisbane (Morgan, 2024)	35
	Figure 11: A Synthesis of the Theoretical Framework (Morgan, 2024).....	37
	Figure 12: Responding to Research Questions	38
	Table 1: Inclusion Criteria for Research Methods	18
	Table 2: Overview of Anonymised Interviewees	21
	Table 3: Limitations of Research Methods	22
	Table 4: Key Barriers Identified in the Interview Process	23
	Table 5: Key Opportunities Identified in the Interview Process	29

Acknowledgements

This Master's Degree in Spatial Planning at Utrecht University is likely to be my final academic piece at university and the end of my student experience here in Netherlands. It has been quite the journey, and I would like to thank a number of notable people that have contributed and helped me to succeed in this challenging endeavour.

Firstly, I would like to thank Prof. Niki Frantzeskaki for supervising my thesis, her valuable knowledge and experience, the numerous online Microsoft Teams meetings, and her continual support throughout both the Advanced Research Methods (GEO4-3120) course and the JAAR Master's thesis Spatial Planning (GEO4-3111). In addition, I would like to thank Prof. Katinka Wijsman who has contributed to the reviewing process of the thesis as well as all other lecturers from the Spatial Planning Master's Degree who have imparted useful information within this area of study.

Furthermore, thanks to all my interviewees from Brisbane who have offered their time and knowledge throughout this research process. They have all significantly assisted with conducting this study and facilitating a greater understanding in sustainable development and the potential of Brisbane becoming a circular city.

Lastly and most importantly, I would like to thank my family, friends, and partner who have provided overwhelming support, encouragement, and guidance during my studies, in particular my partner, who joined me abroad and has been with me every step of the way. I'm always so grateful in having this support in my life.

Abbreviations

BCC – Brisbane City Council
CCD – Circular Cities Declaration
CE – Circular Economy
GHG – Greenhouse Gas
GlobalABC – Global Alliance for Buildings and Construction
ICLEI – International Council for Local Environmental Initiatives
IFC – International Finance Corporation
IPCC – Intergovernmental Panel on Climate Change
ISCA – Infrastructure Sustainability Council of Australia
IS – Infrastructure Sustainability
LCA – Life-Cycle Assessment
MEDC – More Economically Developed Country
SDG – Sustainable Development Goals
SES – Social-Ecological Systems
UN – United Nations
WCED – World Commission on Environment and Development

Abstract

The evolving challenges of climate change and urbanisation have forced cities to reinvent new approaches to reduce resource consumption and promote sustainable development designs to minimise environmental impacts. The development industry is central to this transition away from a linear economy being the sector that contributes most significantly to global carbon emissions. The current prioritisation of non-renewable resources requires an operational shift to a circular system. Bio-based building materials can be an effective alternative in achieving sustainable design in construction to help mitigate climate-related problems, supporting this redirection to a circular economy. Mass timber is a renowned bio-based construction material that has numerous environmental benefits, however, having only recently emerged in modern development, there is a lack of education and application which presents a barrier to this renewable resource.

In this research, a systematic review of academic published literature was conducted relative to sustainability and sustainable development, the circular economy, and bio-based building materials to assess these state-of-the-art concepts and extract a comprehensive set of data using snowballing techniques. The study implemented a circular economy framework, which instilled requirements and actions to assist in achieving this shift away from the linear system. Multiple research methods have been undertaken, including case study research on the Australian city of Brisbane as well as semi-structured interviews, to explore industry knowledge and understand the barriers and opportunities of building materials from key stakeholders. The results identified a number of interconnecting barriers, opportunities, and key stakeholders that play important roles in the transitional shift towards Brisbane becoming a circular city. Notable findings highlighted the need for piloting, planning incentives and policy initiatives to help change traditional values and provide education to the industry in the benefits of bio-based building materials. Whilst Brisbane and other Australian cities would be well-suited for a circular city approach, further research is considered necessary and has been recommended as part of this study.

*Keywords and concepts: **Bio-Based Building Materials, Circular Economy, Mass Timber, Sustainability, Sustainable Development.***

1.0 Introduction

Since the late 20th century, climate change has been internationally recognised as a momentous challenge facing the future development of cities and countries globally. While the impacts of climate change remain disputed, the increasing pressures of population growth and resource consumption are becoming more and more apparent, leading to management uncertainties in spatial planning and development. The Intergovernmental Panel on Climate Change (IPCC), formed by the World Meteorological Organization and the United Nations (UN) in 1988, have stated that climate change is already partially understood with the complexities and uncertainties capable of being reduced by further research (IPCC, 1992, p.53). The IPCC have recently published the sixth Climate Assessment Report (2022), determining that the current unsustainable development patterns are increasing exposure of ecosystems and people to climate hazards (IPCC, 2022, B.2). Should these global development patterns continue at this unsustainable rate, the spatial growth of cities will result in irreversible consequences as climate change impacts and risks are becoming increasingly complex and more difficult to manage (IPCC, 2022, B.5). This global phenomenon requires immediate attention to safeguard the future from our own self-condemnation, and it is the role and responsibility of More Economically Developed Countries (MEDCs) to demonstrate this important transition to becoming more sustainable. If no substantial changes occur, growth opportunities will be severely limited, natural ecosystems and landscapes significantly degraded, consequential increases in global temperature, as well as animal extinction, which may result in the Earth becoming unrepairable.

The development industry, which comprises of various public, private, and governmental organisations, is one of the major influencing factors on global growth and building patterns as this sector creates major pressures on nature through the demand for raw materials (Yadav & Agarwal, 2021). *“The growing density of urban environments across the globe has consequences for the materials used by the building sector; while smaller buildings were historically made using local biobased materials, they have been increasingly replaced by larger, carbon-intensive concrete and steel structures”* (Keena et al, 2022, pg. 1). The current state of industrial systems indicates a distinct linear movement that has become resource-intense, having limited provisions for biodiversity and ecosystem services, and is mostly based on these non-renewable resources (Yadav & Agarwal, 2021). The 2020 Global Status Report for Buildings and Construction detailed that the global building energy consumption has been significantly increasing with the requirement for urgent strategy, noting that the building sector accounted for 38% of total global energy-related CO₂ emissions (GlobalABC, 2020). It was further identified by the Global Alliance for Buildings and Construction (GlobalABC) that the emissions from the operation of buildings were at the highest-ever level in 2019, showing a distinct movement of the sector away from contributing to the Paris Agreement goals established at the UN Climate Change Conference in Paris, France, 12 December 2015 (GlobalABC, 2020). Whilst there is an immediate need to get the building sector on track to achieving the key objective of net-zero carbon by 2050, there have been other positive developments in the industry seeking innovative sustainability improvements in building design. For example, in 2019, investment in energy-efficient buildings had increased for the first time in three years, with building energy efficiency across global markets increasing to USD 152 billion (GlobalABC, 2020). Furthermore, the International Finance Corporation (IFC) has estimated that green building investment in emerging market cities will reach USD 24 Trillion over the next decade alone, representing one of the biggest global investment opportunities (IFC, 2019). Investment in new, innovative designs and materials may be the pathway to improve efficiency and reduce costs while also playing an important role in minimising greenhouse gas (GHG) emissions in new developments.

The World Cities Report 2022 recognised that over the past seven decades, cities had experienced significant population growth and notable demographic ‘megatrends’, such as mass urbanisation, resulting in considerable implications for social and economic development (UN Habitat, 2022). There has been an unprecedented building boom occurring in many global cities, which is expected to continue in order to deliver sufficient housing and infrastructure for the current population growth trends. These demographic trends have been depicted in Figure 1 overleaf, illustrating the continual global population growth expected up until 2070. Whilst it was documented in the report that the share of the global population in cities is expected to increase at a reduced rate, there remains many

BRISBANE'S TRANSITION TO A CIRCULAR CITY

challenges still to be faced from the urbanisation patterns of cities. *“Urbanization undoubtedly presents a unique opportunity for social and economic progress. On the other hand...it also presents challenges when planning systems and public institutions are not equipped to deal with the challenges posed by rapid urbanization”* (UN Habitat, 2022, p.39). This challenge also presents an opportunity for these cities to transition towards more sustainable development designs, supporting improved efficiency and operational performances in the building sector and realising the potential of new emerging technological advancements.

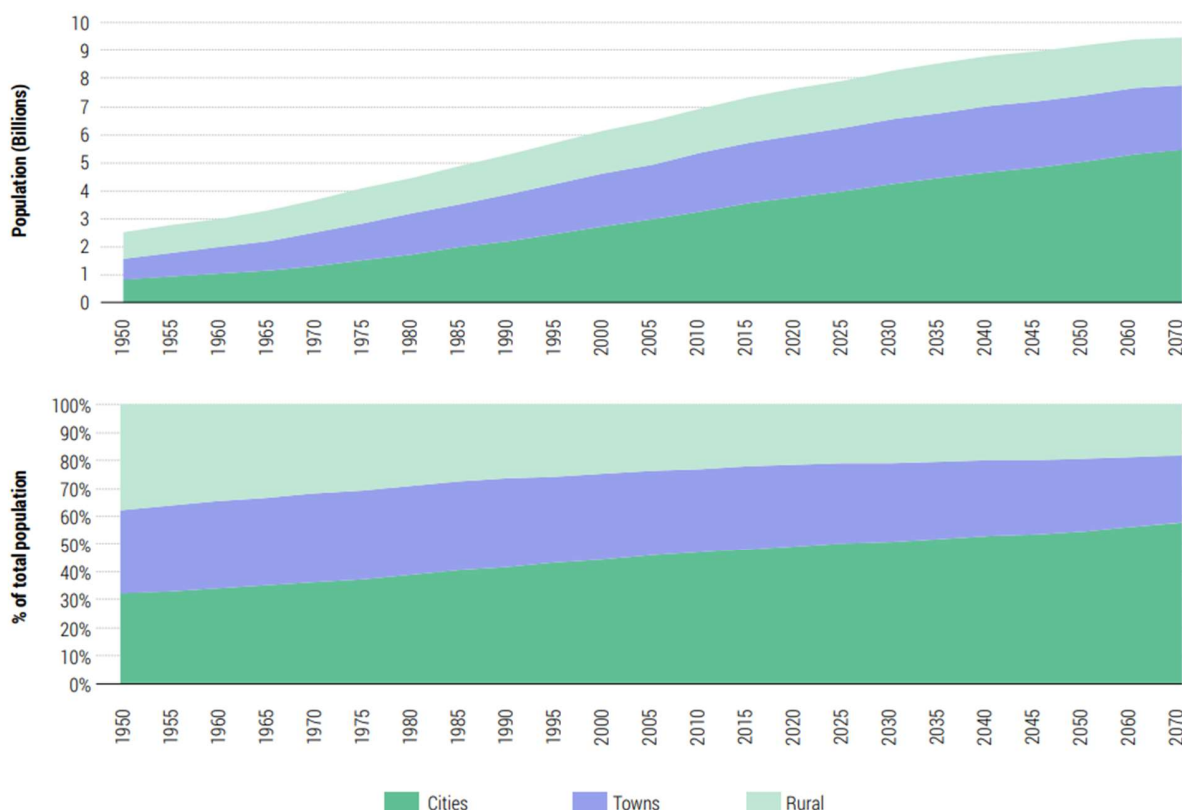


Figure 1: Evolution of population by degree of urbanisation 1950–2070 (UN Habitat, 2022, p. 40)

Changing the way in which resources are managed and processed can have sustainable implications to the development industry, subsequently leading to the integration of new innovative concepts. Yadav and Agarwal have identified that *“...the growth of sustainable features within the building industry has eventually mitigated the climate-related problems such as global warming or the gradual exhaustion of resources on a worldwide scale”*, further recognising that building materials consume approximately 40% of energy yearly in their life cycle stages (Yadav & Agarwal, 2021, p. 2896).

The circular economy concept has gained momentum in the 21st century, with much academic research aiming to provide a comparative review of the advantages and disadvantages of this sustainable system. Wastling et al (2018) describes the circular economy concept as more of a vision, which seeks regenerative and restorative innovative designs for how the global market can operate. Whilst this ‘vision’ has been adopted by many global cities as a mechanism to become more sustainable, the implementation and application of this concept remains undefined and continually debated. Notwithstanding, many authors (e.g. Elia et al, 2017; Fleischmann, 2019) have identified benefits of this circular system in transitioning away from carbon intensive buildings and materials and contributing to

BRISBANE'S TRANSITION TO A CIRCULAR CITY

the sustainable development of cities. However, it has been acknowledged that further education and application of this concept is needed.

Bio-based building materials would be an effective and sustainable approach in the transition to a circular economy. Research suggests that these renewable materials could have substantial implications for the operationality of buildings to become more efficient, sustainable, and lead to significant reductions in GHG emissions. *"Finding ways to develop environmentally friendly and bio-based building materials may be a crucial aspect of sustainable building that have a limited impact on natural ecosystems"* (Yadav & Agarwal, 2021, p. 2896). According to Yadav & Agarwal (2021), mass timber is a renowned bio-based material that has become increasingly employed within the development industry over the last few years. *"Mass timber buildings have demonstrated over 30% lower operational energy demands compared to similar concrete buildings, and 40% savings in GHG, while also comparing favourably in terms of ozone depletion, global warming, and eutrophication when compared with concrete buildings"* (Keena et al, 2022, p. 2). Mass timber has previously been limited to low-rise buildings due to structural performance uncertainties but has since shifted to high-rise development as a result of architectural practices and aesthetical value of providing strong linkages with nature (Yadav & Agarwal, 2021). Whilst there is evidence that the market of bio-based materials is expected to expand across sectors in the near future, there still remains uncertainties and barriers in the development industry, specifically relating to application and production (Keena et al, 2022). An increasing demand for sustainable alternatives both from a consumer and business perspective remains and, therefore, it is critical to understand what barriers exist and how they can be managed. This will pave way for new opportunities within the development industry and drive change in an expanding market.

1.1 Research Objective and Research Questions

In order to gain a greater understanding of sustainable development application within the development industry, there needs to be further research on the barriers and opportunities that are being encountered in the sector and how to enable a shift away from the current linear system. Whilst there has been new research on Australian cities moving toward a circular economy, there is a distinct knowledge gap on how building materials can assist with this transition. Bio-based building materials, such as mass timber, may be an essential link in finding a resolution to this transition to a circular city, with the following question being formulated using Brisbane, Australia as the primary case study.

What are the barriers and opportunities of bio-based building materials in Brisbane's development industry and the roles they play in transitioning to a circular city?

This research question raises three specific sub-questions needed to broaden the understanding of bio-based building materials within the industry and its potential role in promoting sustainable development. More specifically, these research sub-questions seek to explore and evaluate the inclusion of bio-based timber materials and how they can contribute to the sustainable transition to a circular economy. These sub-questions are as follows:

- 1. What are the benefits and limitations of bio-based building materials to the development industry?***
- 2. How has mass timber been incorporated in Brisbane's development?***
- 3. Who are the key stakeholders involved in influencing the barriers and opportunities of this sustainability transition within the development industry?***

To first understand the concept of bio-based building materials, sub-question 1 seeks to provide a background on the benefits and limitations of bio-based timber materials and its value to sustainable development and the circular economy. This information will demonstrate whether the inclusion of bio-based timber materials can be advantageous to the development industry in meeting key sustainability targets and supporting the transition away from the linear system to a more circular economy. Sub-question 2 seeks to establish an empirical analysis on mass timber in present development. This evaluation of existing buildings within the case study city of Brisbane can assist

BRISBANE'S TRANSITION TO A CIRCULAR CITY

in recognising the overall barriers and opportunities for bio-based timber use in the construction industry. Lastly, sub-question 3 identifies the relevant stakeholders within the industry to gauge and understand the role they play in influencing sustainable changes to development. Addressing these three sub-questions will provide the contextual knowledge needed to respond to the overarching research question.

2.0 Literature Review

2.1 Sustainability and Sustainable Development

Sustainability has become an overarching strategy for the development and growth of cities in order to directly contribute to addressing these 'wicked problems' impacting modern society such as climate change, resource depletion, and environmental degradation. The world is in a period whereby the preceding adverse impacts from ongoing human activities on the Earth's climate and biodiversity values are almost considered 'irreversible' and being specifically branded 'the Anthropocene' (Knight, 2015). It is evident that strategic action is critically required, with the implementation of sustainability goals being more important than ever.

The 17 Sustainable Development Goals (SDGs) were established following the 2030 Agenda for Sustainable Development, adopted by all UN Member States in 2015, to instigate necessary actions required by all countries to achieve improvements in many aspects of health and education, inequalities, and economic growth, all while minimising the effects of climate change and environmental degradation (UN, N.D.). These objectives demonstrate strong intentions for improved sustainability outcomes. However, with these goals expected to be achieved by 2030, many countries are still far from progressing and meeting these sustainability targets. For example, SDG 11 seeks to make cities and human settlements inclusive, safe, resilient, and sustainable. The recent progress update on Target 11.1 determined that since 2022 "*nearly 1.1 billion people lived in slums or slum-like conditions in urban areas, with an additional 2 billion expected to live in slums or slum-like conditions over the next 30 years*" (UN, 2023, SDG 11). Another example is SDG 13, which seeks to take urgent action to combat climate change and its impacts, yet the progress on Target 13.3 has identified that, from an analysis of 100 national curriculum frameworks, 47% do not even mention climate change (UN, 2023, SDG 13). The progress overviews of both SDG 11 and SDG 13 are illustrated in Figure 2, overleaf. In addition to the lack of progress on these SDGs, it was deemed by UN Statistics Wiki (2024) that only 103 out of the 193 countries have submitted SDG reports to the UN so far, demonstrating that there remains a severe lack of understanding and capabilities for many countries around the world. Therefore, in order to provide sufficient background knowledge for the methodology of this study, the concepts of sustainability and sustainable development must be narrowed and defined.

BRISBANE'S TRANSITION TO A CIRCULAR CITY

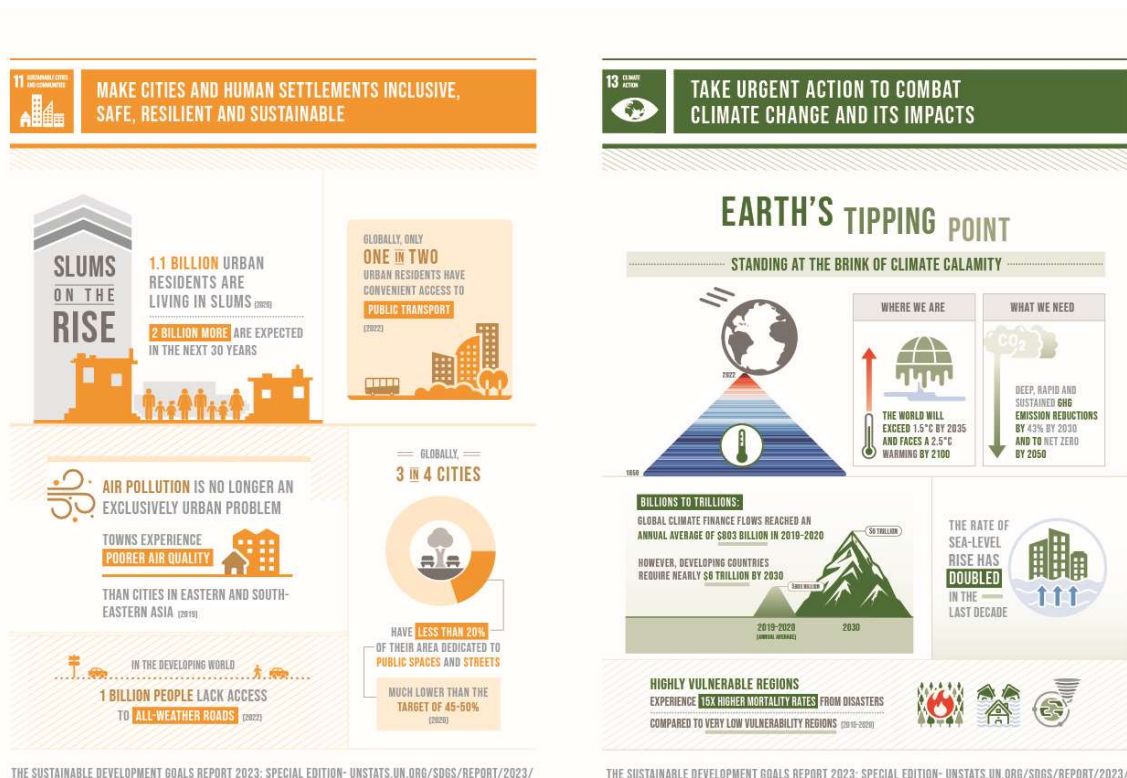


Figure 2: Progress Overview of SDG 11 & 13 (UN, 2023)

Despite the academic interpretations and governmental policy interventions, the concepts of ‘sustainability’ and ‘sustainable development’ remain complex and dynamic, leading to uncertainties in how to progress the current urban systems and achieve global sustainability targets. Geissdoerfer et al (2017) estimates that 300 definitions of sustainability have been formulated. “Complex and important concepts, such as sustainability, are not always subject to precise definitions, nor is it always absolutely necessary, and can often be more dialectical than analytical” (Muriuki et al, 2016, p. 414). Other authors have recognised how difficult sustainability is to define, given the many complexities and everchanging challenges that surround the concept. Purvis et al (2018, p. 681) described sustainability as an “open concept with myriad interpretations and context-specific understanding”. For the purposes of this paper, it is appropriate to provide a contextual definition of the term ‘sustainable development’, which is to be consistently adopted throughout this research given its commonalities within the research questions and sub-questions. The Brundtland Report, published by the World Commission on Environment and Development (WCED) in 1987, defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 37). This established definition has been frequently referred to in academic literature to define the concept. However, the Brundtland Report, later expands the definition to:

“...a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development; and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations” (WCED, 1987, p. 38).

Whilst the Brundtland Report was formulated in late 20th century, it is still prominently recognised and commonly referenced in academic literature today. This definition demonstrates a range of interconnected elements that are related to this study and the review of circular economy concept, bridging the numerous factors that shape the way in

BRISBANE'S TRANSITION TO A CIRCULAR CITY

which we live. It is a definition that also seeks to encompass the social, economic, and environmental foundations of development and its importance in terms of current and future generations. As such, this definition will be adopted throughout this thesis to provide a consistent understanding of the concept.

2.2 The Three Pillars of Sustainability

This understanding of sustainability and sustainable development has been attributed to a number of concepts and perspectives that remain applicable to modern development. One key concept that has had particular significance in academic literature is the three pillars of sustainability, which was first discussed in the Brundtland Report (1987). This model employs three 'pillars' that demonstrate the important interconnected relationships between economic, social, and environmental factors or goals, as shown below in Figure 3. Purvis et al (2018) identifies a number of notable authors, such as Barbier (1988) and Hancock (1993), that have advocated and presented their own perspectives on this concept, supporting this attempt to reconcile or establish a balance between these factors to achieve a sustainable focal point. Whilst this concept was constructed before significant research into sustainability was recorded, the overarching principles are increasingly relevant in the urban growth of cities. These three interrelated factors can be applicable to assessing and determining the very barriers and opportunities of other sustainable concepts, such as the circular economy.

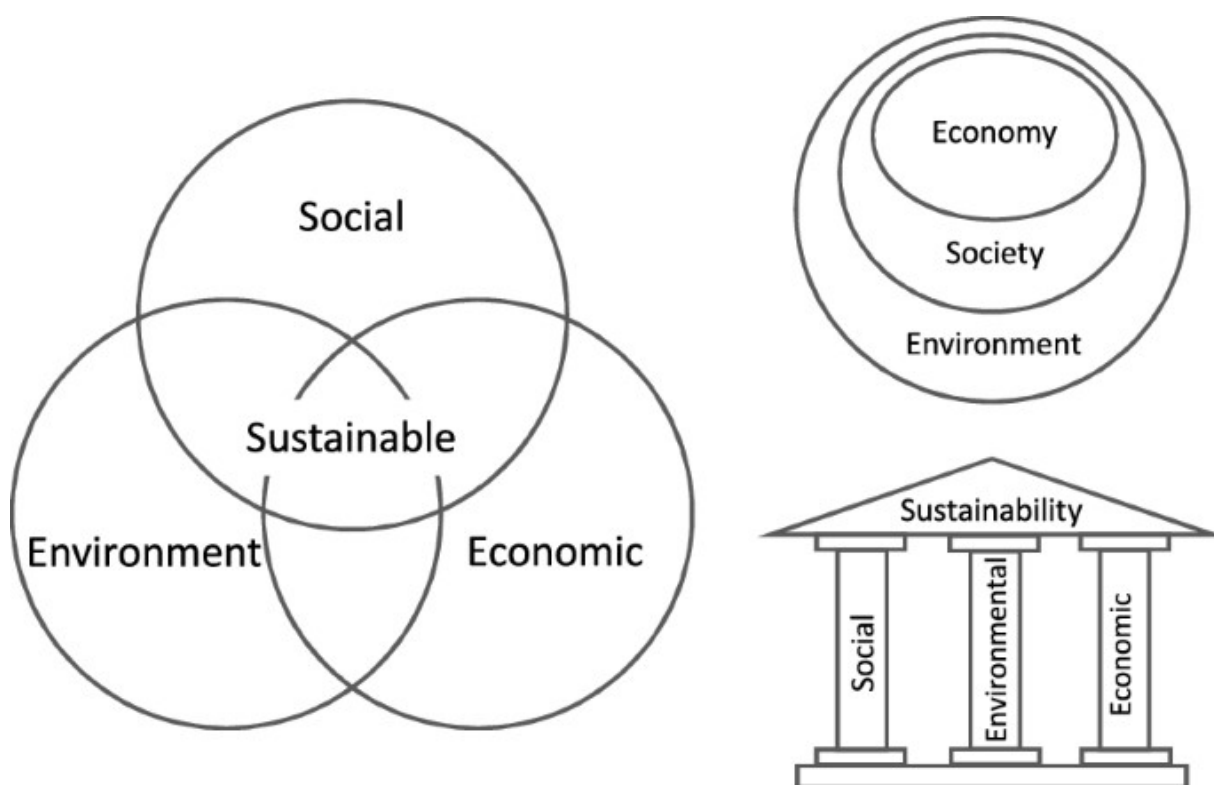


Figure 3: Three Pillars of Sustainability (Purvis et al, 2018)

Whilst the three pillars model of sustainability has gained widespread traction in defining this 'fuzzy' concept, there is a lack of theoretical development evidence, with no original version of text found that provides the foundation of this approach. Purvis et al (2018, p. 685) argue that "as early as 2001, this approach has been presented as a 'common view' of sustainable development, so commonplace it seems not to require a reference". Recent literature suggests

BRISBANE'S TRANSITION TO A CIRCULAR CITY

that there are more pillars of sustainability to consider, such as institutional, cultural, and technological factors that are becoming increasingly more relevant in sustainability movements. This is again identified in the ways in which the UN have developed the SDGs, integrating and adopting 17 targets to achieve sustainable development rather than limiting it to the three individual pillars of sustainability. Therefore, it is clear there are differences with how sustainable development has been globally defined, noting how complicated and broadly interpreted this concept is considered and the role of many interconnecting factors. Evidently, the three pillars model has become a backbone concept to adequately characterise the involving elements in sustainable development, leading to how these elements can be broken down to identify depth and understanding.

2.3 Circular Economy in the Urban Context

The circular economy concept has become a key field of academic research that has been regularly theorised in an attempt to apply the sustainable processes to cities and regions on both micro and macro scales. The intensifying impacts of climate change have sparked a pressing need to transition to more sustainable socio-technical systems, with this circular strategy focusing on waste prevention, resource efficiency, and the dematerialisation of the industrial economy (Geissdoerfer et al. 2017). There have been a variety of academic input related to defining the processes involved with a circular economy system and this remains up for interpretation. Suarez-Eiroa et al (2019) has reviewed and identified three common theoretical attributes under this circular economy paradigm:

1. *minimizing inputs of raw materials and outputs of waste;*
2. *keeping resource value as long as possible within the system; and*
3. *reintegrating products into the system when they reach the end-of-life.*

Noting the above life cycle elements of the circular economy practices and the need to narrow these sustainable processes into more urban contexts, the vision for circular cities has been sought to rejuvenate the operational systems in which cities have been traditionally built upon. The Circular Cities Declaration (CCD), which is managed International Council for Local Environmental Initiatives (ICLEI) for Europe defines a circular city as "*...one that promotes the transition from a linear to a circular economy in an integrated way across all its functions in collaboration with citizens, businesses and the research community*" (CCD, 2020, p.1). The ICLEI Europe released the CCD Report 2024 on the progress of European cities in transitioning towards a circular economy. The CCD Report 2024 confirms that 54 cities across 18 countries submitted detailed report updates that assist in providing insight and experiences into how these cities are implementing the principles of the circular economy concept, measuring progress and how they are regenerating nature (CCD, 2024). These cities are identified in Figure 4 overleaf, and include Budapest, Copenhagen, Bruges, Rotterdam, Porto, Helsinki, and Zurich. Furthermore, the report identified six actions necessary to enabling cities to accelerate their circular economy progress, noting that this requires cooperation of policymakers, businesses, civil society, and citizens:

1. *Work towards common circular economy metrics;*
2. *Set more ambitious targets, including on consumption-based emissions;*
3. *Integrate circular economy approaches across city departments to unlock resources;*
4. *Innovate circular systemic solutions;*
5. *Advocate for a new paradigm; and*
6. *Embed nature into all decision-making processes.*

This strategic implementation of the circular city model in European cities demonstrates the potential for this to be replicated in other cities around the world, using these valuable insights to help identify the main barriers and opportunities experienced by cities in their path towards a circular future.

BRISBANE'S TRANSITION TO A CIRCULAR CITY



Figure 4: Current Signatories of the Circular Cities Declaration (CCD, 2024)

While it is evident that the principles of a circular economy have been internationally recognised for the reduce, reuse, and recycle processes, leading to major environmental and economic benefits, there remains unresolved questions and limitations that continue to be scrutinised. For example, academic literature suggests that resource use is the only dimensions being considered as part of this process. However, there are many other factors to be considered, especially when implementing the circular economy model to urban systems. Pomponi & Moncaster (2017) acknowledged that there is a neglect to the complexities that are inherent within building design. Historically, buildings have been constructed to have substantial lifespans and, therefore, when implementing principles of circularity into urban development these would generally only be applicable to new developments. This was further discussed by Pomponi & Moncaster (2017) using the example of the UK, outlining that 80% of the buildings that will be standing in 2050 have already been built, with an average lifespan of 132 years. This presents a serious limitation to the vision of a circular city and should be considered when applying sustainable processes within the development industry.

BRISBANE'S TRANSITION TO A CIRCULAR CITY

2.4 Bio-Based Materials

The introduction of bio-based materials has been linked with the processes of a circular economy due to these materials being renewable and able to facilitate sustainable development outcomes. Yadav & Agarwal (2021, p. 2895) define bio-based materials as materials that “*principally accommodate a substance(s) resulting from existing matter such as biomass and either arise naturally or product created by developments that use biomass.*” Bio-based materials, such as bamboo, leather, wool, and silk are starting to become utilised within development, with others, such as timber, having a long history in the construction industry. Suttie et al (2017) separates bio-based building materials into two main categories, forest products and agriculture/animal products. The market for bio-based building materials is expanding as a result of increasing demand for sustainable products from companies and consumers and rising support from governmental agencies (GQ Research, 2023).

Timber is a key bio-based building material that has been integrated into development globally, with the recent establishment of mass timber high-rise buildings showing considerable promise. One notable example is the recently approved 50-storey mass timber mixed use development in Western Australia, which will be regarded as the tallest timber tower in the world (refer to Figure 5). It was deemed that the rapidly shifting climate was the main driver behind the carbon-negative building, which also supports an “*embedded power network harnessed through solar and wind technologies, along with on-site food production, waste management and biophilic vertical landscapes*” (Tabet, 2022, paragraph 7). According to Kremer & Symmons (2015), these technologies of mass timber construction offer important sustainability benefits for the development industry as it represents a lower embodied energy consumption than many other building materials, such as steel and concrete. In addition, the recyclable nature of timber demonstrates a consistent characteristic of the circular economy, allowing previously built timber structures to be reused in new development, thus expanding their overall life cycle. While timber is a commonly used building material, there is clear potential to incorporate other bio-based building materials with the development industry to unlock further benefits.



Figure 5: Approved Mass Timber Tower in Perth, Australia (Tabet, 2022)

BRISBANE'S TRANSITION TO A CIRCULAR CITY

Despite the exhibited advantages of bio-based building materials within modern development, there remains limitations that continue to decelerate the implementation of these materials and force the utilisation of other out-dated, artificial, and chemically produced materials. Yadav & Agarwal (2021) discuss these challenges, classifying bio-based building materials as more flammable and having more uncertainty than masonry and steel.

"Combustibility confines their use as a construction material because of the limitations in building guidelines in most nations, particularly in larger and taller structures" (Yadav & Agarwal, 2021, p.2901). Other limitations have also been considered include materials costs, forestry production and manufacturing, consumer preferences, awareness, and governmental policy and regulation (GQ Research, 2023). These barriers may be considered typical for new market products and the establishment of a local supply chain, with time being a crucial factor for facilitating this shift to more sustainable building materials.

3.0 Theoretical Framework

This section of the paper seeks to adopt the circular economy theory and the concept of sustainability as a lens to investigate and examine the research gap described above, drawing on the research questions and the underlying assumptions for analysing this global phenomenon. Pacheco-Vega (2018) defines a theoretical framework as being *"...comprised of the different theories and theoretical constructs that help explain a phenomenon"*. Following the background of these concepts in the literature review, a theoretical framework has been established to model the circular city and its relationship with sustainability.

This concept of the circular economy has been unfolding gradually and is now being applied to cities as a strategy to meet sustainability targets, transitioning economic sectors to demonstrate an alternative system away from the unsustainable linear economic model that currently exists. *"Globally, 'circular economy' principles are being adopted by businesses and governments, as a route to resource efficiency in the face of rising material prices and climate change"* (Prendeville et al, 2018, p.171). There is a growing body of literature outlining the role of the circular economy in transitioning cities to facilitate improved sustainable principles, with various frameworks having been developed. When applying the circular economy to the built environment, there was often a link back to the three pillars of sustainability (economy, environment and society) and, in some cases, additional elements were considered. For example, Pomponi and Moncaster (2017) described three (3) more defining elements that were deemed to be missing from the triple bottom line view, which included *"the role of governments (i.e. policy), the role of matter (e.g. design, technology, materials) and the role of individuals (i.e. behavioural)"*. Many other frameworks build upon the origins of the circular economy, focusing on the five main phases: material input, design, production and delivery, consumption, and end of life resource (Elia et al, 2017). These frameworks are more targeted to the circular system of resources while incorporating sustainability principles, which would be considered more effective in the application of bio-based building materials and mass timber.

Elia et al (2017) have formulated a 'Circular Economy Framework' (refer to Figure 6 overleaf) that has integrated actions from the Ellen MacArthur Foundation (2013), measurable requirements from a European report (EEA, 2016), and three main fields of intervention of the circular economy paradigm outlined by Ghisellini et al. (2016). This theoretical framework will be implemented and applied to answering the research question of ***'What are the barriers and opportunities of bio-based building materials in Brisbane's development industry and the roles they play in transitioning to a circular city?'***, using this circular economy theory to explain the transition for Brisbane away from the existing linear system.

BRISBANE'S TRANSITION TO A CIRCULAR CITY

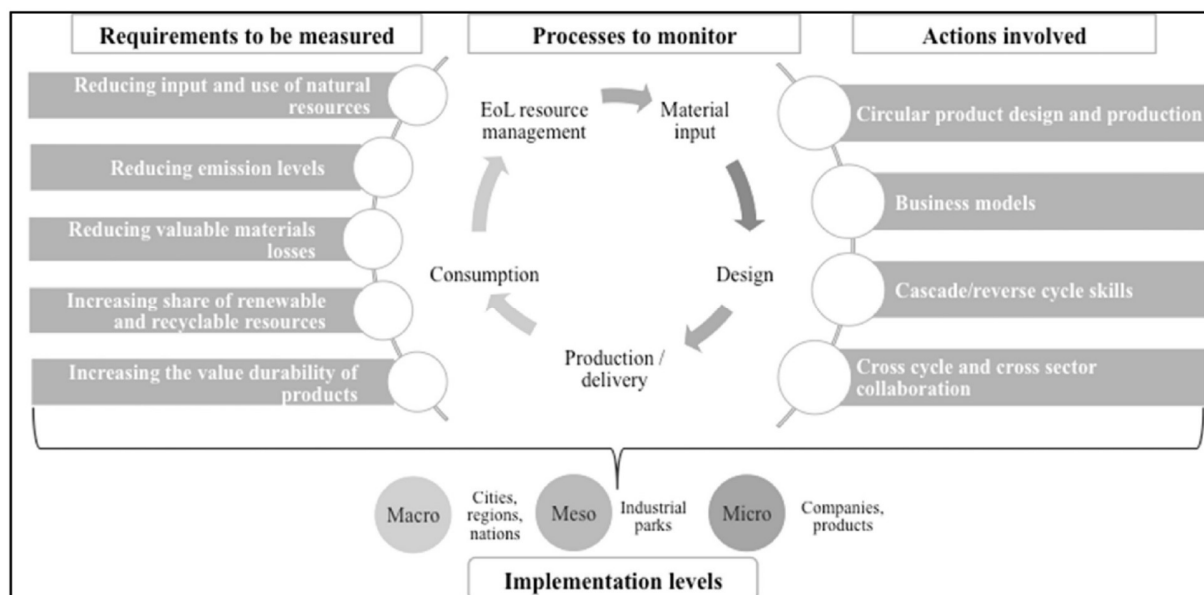


Figure 6: The Circular Economy Framework (Elia et al, 2017)

The reason for implementing the Circular Economy Framework is that this theoretical framework has the properties to demonstrate this shift away from the linear system and understand what actions and requiring measures can assist in achieving this goal. This framework from Elia et al (2017) aims to evaluate the possibility of filling the current gap in the environmental evaluation of circular economy strategies on the micro level with some of the several methodologies already existing and utilised in the industrial and service sector. It is therefore apparent that the framework would have relevance to this specific study, noting a similar sector focus and evaluation subject, indicating the potential for the implementation of interconnecting barriers and opportunities that can have a role in facilitating this transition to a more circular economy.

Noting the theoretical framework above, there remains labelled assumptions regarding the application of the circular economy to cities globally. Petit-Boix and Leipold (2018) have analysed and recognised a number of these assumptions, with the following having specific relevance to this study:

- The Circular Economy is the best approach for sustainable transitions in cities;
- The strategies of implementing the circular economy have not been fully captured, with a lack of initiatives and urban planning policy;
- The complexity of social and urban processes in different cities and regions;
- The required data is not publicly available (e.g., urban planning processes or specific consumption patterns); and
- Time of application and transition has not been taken into account.

Therefore, with these valid assumptions considered, there remains a research gap with the potential for further research to be undertaken and implemented in various cities and regions around the world to assess and examine the application of this concept.

4.0 Methodology

The methodology of this study comprises of two (2) key qualitative techniques, case study research and semi-structured interviews, to identify and collect the necessary data to respond to the overarching research question:

What are the barriers and opportunities of bio-based building materials in Brisbane's development industry and the roles they play in transitioning to a circular city?

MacCallum et al. (2019, p. 7) defines 'research methods' as "systematic, broadly accepted, concrete procedures for acquiring new knowledge" and clarifies that in this definition, 'broadly accepted' should not be understood as 'universally accepted' and 'concrete' does not necessarily mean that the researcher needs to be dealing with 'hard' facts. The research methodology for the selected case study of Brisbane, Australia carried a focus on a qualitative data approach, initially using a desktop analysis to systematically review and gather secondary data from scientific sources, publications, and academic literatures from November 2023 to June 2024. Snowballing techniques were applied to circulate a greater variety of credible sources. Wohlin (2014, Ch. 1) defines snowballing as "using the reference list of a paper or the citations to the paper to identify additional papers", identifying that this technique "could benefit from not only looking at the reference lists and citations, but to complement it with a systematic way of looking at where papers are actually referenced and where papers are cited".

Secondary data was collected through a comprehensive search and selection process from multiple databases, including, but not limited to, Google Scholar, Scopus, and ScienceDirect. This initial process involved a set of identified criteria (Table 1) to allow for the narrowing of studies and to provide a more concrete approach to acquiring this knowledge. The resulting analysis was used to provide background knowledge and credible references to enable effectiveness in the two key qualitative techniques.

Table 1: Inclusion Criteria for Research Methods

Criteria	Description	Number of Documents
Year of publication	Published from a time period between 2015–2021	40
Geographical location	Brisbane and Australia as a general focus	12
Language	English only	52
Keywords	Circular economy, Bio-based materials, Mass timber, Sustainable development, Sustainability, Australia, Brisbane	44

4.1 Case Study Research

Case studies are considered appropriate and useful in investigating global phenomenon, with circular economy strategies emerging and being applied within cities. "Across the Australian landscape, the drivers to go circular have gained ground with the increasing consciousness on the fundamental importance of environmental sustainability in uninterrupted growth" (Halog et al, 2021, p.284). Brisbane, the capital city of the state of Queensland (refer to Figure 7), has been the case study chosen for this research paper, with the major city having a distinct opportunity in its recognition as a leader for sustainability. "In a national context, Queensland...lags far behind other states in Australia when it comes to waste re-use and recovery at 44.5%; South Australia, by contrast, has close to an 80% re-use and recovery of waste, while the national average is 61%" (Fleischmann, 2019, p.384). While Brisbane City Council (BCC) have recognised that Brisbane have been large advocates for sustainability over the last 20 years (BCC, 2024), there still remains evidence of a research gap. It has been noted throughout the desktop analysis that there is a lack of scientific literature applied to this capital city, resulting in a limitation of this study. Notwithstanding, this

BRISBANE'S TRANSITION TO A CIRCULAR CITY

paper analyses state-of-the-art concepts and their revolutionizing potential to integrate into Brisbane's development industry through the application of bio-based building materials.

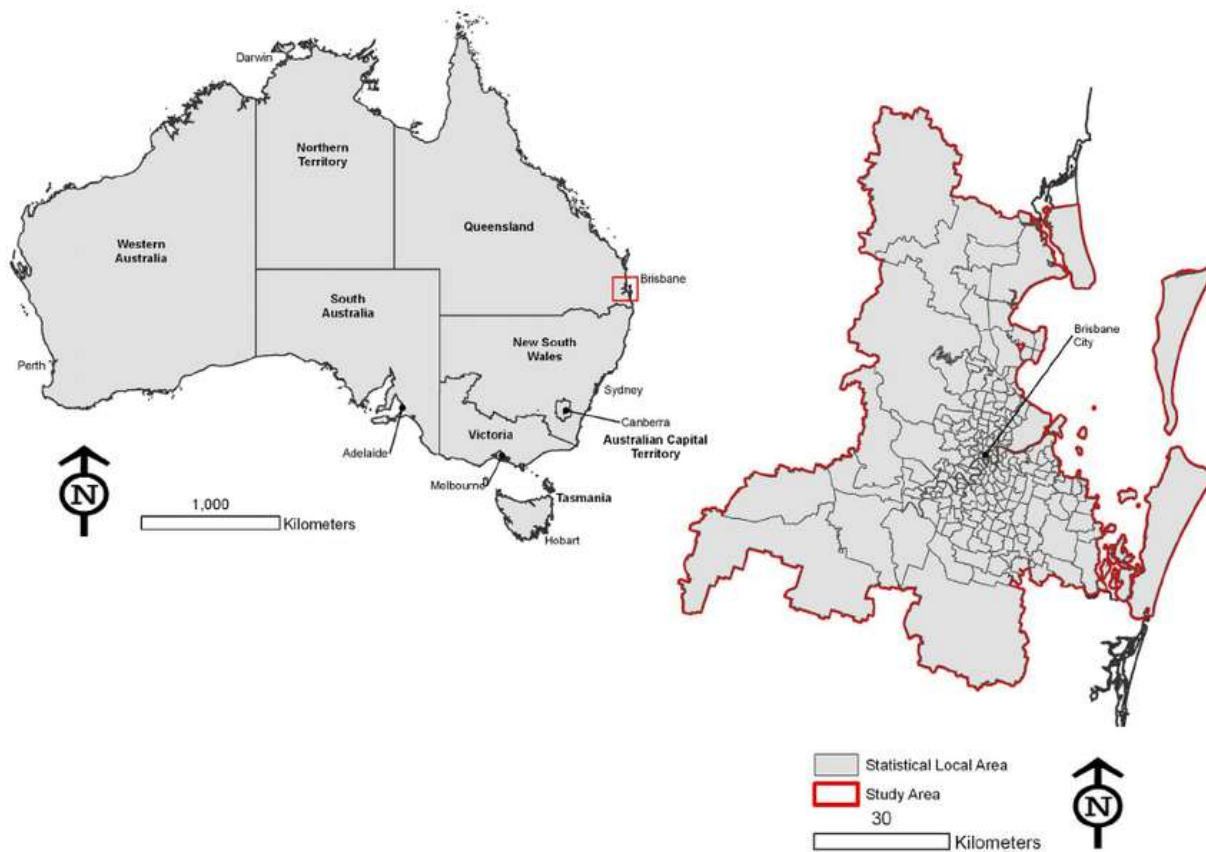


Figure 7: Brisbane Statistical Local Government Area (Hipp et al. 2014)

There is a distinct opportunity with this case study research on Brisbane, with substantial economic and urban growth forecasted over the next eight years coming up to the Brisbane 2032 Olympic and Paralympic Games. “*The Games are set to deliver \$8.1 billion in benefits to Queensland including a \$4.6 billion economic boost to tourism and trade and \$3.5 billion in social improvements such as health, volunteering and community benefits*” (BCC, 2024, p.1). This momentous event is facilitating an acceleration of development by both the public and private sectors, with a targeted push for Brisbane to become one of Australia’s most sustainable cities. Therefore, there is an opportunity to participate in contributing to achieving this goal by providing further knowledge on the potential benefits of bio-based timber materials in the construction industry and transitioning towards a circular city. “*A circular built environment could generate \$773 billion in direct economic benefits over twenty years and save 3.6 million tonnes of CO2 per year in Australia by 2040*” (PwC Australia, 2021, p.14). Whilst Australia has advocated for aspects of sustainable development and design within some policy and business decisions, there still lacks a holistic approach for supporting and incentivising circularity nation-wide (PwC Australia, 2021). It can therefore be recognised that an integrated framework between government and the industry is required to contribute to this transition.

Evison et al (2018) have identified a particular “gap” in the current knowledge of mass timber requiring an examination of consumer perceptions about the use of wood as a construction material and how this affects mass timber construction uptake in Australia. “*Timber construction, emphasized as a renewable resource, will remain novel, as most developers are less confident about using timber in their projects...*” (Evison et al, 2018, p. 131). This knowledge gap, which has extended into the consumer market, demonstrates the lack of available information and

BRISBANE'S TRANSITION TO A CIRCULAR CITY

education of substituted resources such as mass timber. Case study research on Brisbane can provide this knowledge to drive change and generate improvements to efficiency, enabling more circular processes in the development industry.

4.2 Semi-Structured Interviews

The chosen method to obtain this data across the case study of Brisbane is to formulate semi-structured interviews with a range of key stakeholders within this disciplinary field. *"In-depth interviews generate qualitative data through extensive individual interviews and can be structured, with set questions; semi-structured, with guiding questions; and unstructured, with themes that the interviewer would like to cover"* (Shackleton et al, 2022). The recruitment approach will commence with a number of key informants with relevant field knowledge, which are professional acquaintances within the industry and will help facilitate efficient snowballing for the remaining interviews. *"Key informant interviews are used to collect qualitative data in a purposive manner from people with particular relevance to, or who hold useful knowledge for, the study"* (Shackleton et al, 2022, p.111). It was determined that a total of 16 interviews will be sought to enable a broad array of information on the particular barriers and opportunities related to the research question and sub-questions, comprehending any interrelated affiliations. Based on the analysis produced by Guest et al (2006), it was deemed that data saturation occurs by the time of the twelve-interview mark, with the new themes emerging infrequently and progressively. In contrast, the research gathered by Baker and Edwards (2012) identified a total number of 19 interviews as the recommended quantity for qualitative analysis, which included *"a set of succinct 'expert voice' contributions from 14 prominent qualitative methodologists and five 'early career reflections' from those embarking on academic careers"* (Baker and Edwards, 2012, p.42). Whilst the academic literature on determining the ideal number of interviews for qualitative analysis is substantial, there is sufficient research advocating for between ten and twenty interviews, which still allows for a high level of data collection. With regards to the interview processes, interview questions will be prepared in advance through the input of guides, drawing from validated tools and relevant academic sources to allow for concise and well-defined questions. Shackleton et al (2022) provided five main dimensions of social-ecological systems (SES) to generate data and insights in the interview process:

1. *Social-ecological dimensions (e.g. human–nature interactions, values and relational values, stewardship, resource use)*
2. *Institutional dimensions (e.g. governance, management)*
3. *Social-relational dimensions (e.g. collaboration, social learning, power dynamics)*
4. *Contextual dimensions (e.g. history, culture, political systems, knowledge systems, socio-economic systems)*
5. *Individual dimensions (e.g. agency, identity, sense of place, behaviour, perceptions)*

These dimensions have been examined to inform the interview guideline and thus applied in the operationalisation of these interviews. The interview guideline has included a myriad of these dimensions, including but not limited to human-nature interactions and resource use, institutional platforms, collaboration of key stakeholders, historical and political systems, as well as individual identities and perceptions of the development industry. These key dimensions from Shackleton et al (2022) have provided a useful base for the interview guideline and will be reviewed throughout the data collection of interview results.

The interviews have been appropriately recorded, with informed consent, via a mobile phone or through Microsoft Teams to allow for sufficient collection of data that can be correctly interpreted. *"Facts that have been recorded, organised and interpreted to make them meaningful"* (MacCallum et al, 2019, p.9). Additional time will be made available in the interviews to encourage meaningful exchanges that facilitate participants and the interviewer to ask follow-up questions, where necessary. It will also allow time for concluding questions aimed at seeking critical feedback for improving the interview guideline. This process enables further opportunities to gather in-depth data relevant to the study. *"Both in-depth interviews and life histories can be used to bring culturally derived*

BRISBANE'S TRANSITION TO A CIRCULAR CITY

understandings into the assessment of long-term social, ecological, economic and cultural changes in SES" (Shackleton et al, 2022, p.111). Lastly, prior to these interviews being conducted, all relevant stakeholders will be informed of the aim of the research, with sufficient background information provided to allow participants to be aware of what they are consenting to in this interview as well as anonymity for each person(s) participating. No expected results will be discussed prior to the interviews to avoid influencing each participants answers, which would lead to inauthentic results.

Following the conduction of these semi-structured interviews, the use of transcription methods will be employed to gather the information in the most efficient processes to enable appropriate time to revise and analyse this data. Transcribing methods are employed in research to convert speech to text, generally word for word, and is a standard practice when conducting interviews, enabling you to perform detailed analysis (Streefkerk, 2019). Based on research of the most efficient transcription methods, it has been decided that 'Microsoft Teams' will be the platform used for this study, as it is most commonly utilised within Brisbane's development industry and will provide a simple schedule transition for the interviewees. Shackleton et al (2022) describes qualitative interviews as being equally resource demanding, with most interviews recorded and requiring transcription, which again may require additional assistance and funding. Therefore, using these automated methods of transcription will be useful in facilitating an orderly and resourceful outcome with the semi-structured interview process.

4.3 The Interview Process

The semi-structured interview process took place in Brisbane, Australia from the 14th of March until the 12th of April 2024, which included a total of 16 participants interviewed. As evident in Table 2, these interviewees comprised of a myriad of disciplines and experience which held a significant role within the development industry as well as having the opportunity and capability to deliver strong sustainable outcomes. This facilitated a diverse range of perspectives, knowledge, and understandings within the field of study and assisted in providing key information to respond to the overarching research question. A mix of singular and group interviews had taken place, designed to maximise efficiency and support collaborated responses from the interview guideline questions (refer to Appendix 1). Furthermore, all interviewees provided verbal consent for recording the interview to allow for the Microsoft Teams transcription, whilst being anonymised in the results. The organised process of this empirical data collection enabled sufficient insight into the *barriers and opportunities of bio-based building materials in Brisbane's development industry and the roles they play in transitioning to a circular city.*

Table 2: Overview of Anonymised Interviewees

Interviewee	Discipline	Years Experience	Conducted Interview	Location	Consent
1	Director/Architect	40-45 years	Singular	Brisbane	Verbal Consent Provided
2	Senior Town Planner	8 years	Group	Brisbane	Verbal Consent Provided
3	Consultant/Engineer	10 years			
4	Queensland Environment manager	17 years	Singular	Brisbane	Verbal Consent Provided
5	Senior Town Planner	6-7 years	Singular	Brisbane	Verbal Consent Provided
6	Senior Town Planner	7.5 years	Group	Brisbane	Verbal Consent Provided
7	Senior Town Planner	9.5 years			
8	Project Manager	8-9 years	Singular	Brisbane	Verbal Consent Provided
9	Principal Landscape Architect	22 years	Singular	Brisbane	Verbal Consent Provided
10	Senior Quantity Surveyor	16 years	Singular	Brisbane	Verbal Consent Provided
11	Structural Engineer	7 years	Singular	Brisbane	Verbal Consent Provided

BRISBANE'S TRANSITION TO A CIRCULAR CITY

12	Chief Sustainability Officer	7-8 years	Singular	Brisbane	Verbal Consent Provided
13	Planning Manager	8 years	Singular	Brisbane	Verbal Consent Provided
14	Project & Program Officer	8 years	Singular	Brisbane	Verbal Consent Provided
15	Senior Urban Designer	10 years	Group	Brisbane	Verbal Consent Provided
16	Associate Director	7 years			

4.4 Limitations of Research Methods

With all areas of research there are limitations and risks that should be considered and accounted for within the study, noting that some of these limitations are inevitable in each research process chosen. The limitations of research methods refer to potential weaknesses of the study and can affect the validity or generalisability of the results (Hassan, 2024). Furthermore, these limitations can occur at different stages of the study and from various sources. Whilst these limitations are viewed as weaknesses of the study, identifying these pitfalls demonstrates integrity given the transparency and submission to the scientific method. Hassan (2024) outlines a number of common types of limitations in research. Table 3 considers the relevant limitations to this study.

Table 3: *Limitations of Research Methods*

Limitation	Description
Sample Size Limitations	The proposed semi-structured interviews involved a group size of 16 interviewees, with a mix of single and group interviews. The number of respondents may not be sufficient to establish statements regarding the entirety of the development industry.
Time Limitations	The data collection was only achievable during a one-month period and therefore may have affected the quality of the data gathering and analysis.
Selection Bias	The selection of participants was based on snowballing from professional acquaintances in the industry, which may have introduced biasness or personal preferencing, and included randomised disciplines.
Other Confounding Variables	<ul style="list-style-type: none"> - There is a lack of relevant literature surrounding the chosen case study location, which may lead to undefined outcomes. - The circular economy concept remains new, scarcely investigated, and yet to be applied in Australian cities, which may have potential drawbacks. - The complexities with consumer behaviour have not been fully understood in relation to implementing circularity into business models.

5.0 Results

5.1 Key Barriers of Bio-Based Building Materials in Brisbane's Development Industry

The development industry plays a fundamental role in the urban growth of Brisbane and can dictate the application of new sustainable measures to enhance the liveability and operationality of the city. This transitional shift towards a more circular city is largely influenced by tangible barriers that have the power to impact the outcomes of development and design. These barriers are experienced in cities globally, noting that each barrier may be specific to one city and not necessarily universal.

Research sub-questions 1 and 3 have specific relevance when focusing on the key barriers of bio-based building materials, demonstrating an understanding into how these materials are being applied in Brisbane's development industry and the relevant stakeholders that are involved in the process. These key barriers have been identified and illustrated below in Table 4. Table 4 classifies the frequency of each barrier within the 16 interviews that occurred, demonstrating the magnitude each barrier influences within the development industry. Resulting data from the interview transcripts have been incorporated to grasp the interrelated factors of each barrier along with notable excerpts from the interviewees to assist in representing the empirical data.

Table 4: Key Barriers Identified in the Interview Process

Identified Barriers	Frequency in Interviews	Summary	Excerpts from the Interviewees
1. Cost	14/16	<ul style="list-style-type: none"> - Building materials are decided by the client or developer which, in turn, are dictated by costs from a business point of view. - Development is influenced by project costs, profitability and inherently have budgets, which can make it difficult to accommodate more expensive building materials. - Whilst cost is a key driver for projects, finding a balance between innovation and deliverables is achievable, which can be more easily shaped by tools such as cost benefit analysis. 	<p><i>"It is hard, and, you know, cost is that one that always kills you, but they (materials) don't actually have to be that expensive. That's the game."</i> (Interview 1) <i>"So I think it always comes back to that when you are dealing with developers, they have the intent there, but at the end of the day, things can come down to cost and also a cost benefit analysis."</i> (Interview 4) <i>"It's costly and I feel like we haven't found the balance for it yet, but it's something that's achievable."</i> (Interview 5) <i>"When you're a private developer...their key drivers are usually keeping the costs at a minimum."</i> (Interview 6 & 7) <i>"That is a barrier for a lot of projects that you really need a client who is prepared to accommodate that cost in a business case or really take it to another level. The majority of time that is something that once it's presented with a cost and a number next to it and potentially a time impact that becomes a bit hard to</i></p>

BRISBANE'S TRANSITION TO A CIRCULAR CITY

			<i>get it over the line for projects.”</i> (Interview 8) <i>“Developers are more interested in how much is it going to cost me to deliver this thing.”</i> (Interview 9) <i>“I think that’s (cost) obviously the most tangible barrier on the ground.”</i> (Interview 13)
2. Materials and Supply	9/16	<ul style="list-style-type: none"> - The COVID impacts to Brisbane’s construction sector and the pricing/supply of materials played a significant role in stagnant growth and the continuation of cheaper, non-renewable materials such as concrete and steel. - Brisbane has been severely affected by service shortages, as seen by the lack of builders and bricklayers available, which has a flow-on effect to project costs and cuts. - Material availability and accessibility has a major influence on material choice for buildings and can change constantly subject to domestic and international market conditions. 	<i>“There are limitations to every type of building material, and I think timber’s advantage is that it’s coming back to the forefront.”</i> (Interview 2 & 3) <i>“At the end of the day they make their money by finishing projects and if the supply chain is an issue and adds time, significant time cost delays, then there may be a tendency to go to another option.”</i> (Interview 4) <i>“As soon as construction becomes more expensive it gets harder to achieve and there’s been several examples within Brisbane, particularly where it’s proven to be more expensive and more costly to actually refurbish or reuse materials rather than starting from scratch.”</i> (Interview 6 & 7) <i>“With public areas in terms of like safety and having resilient material...it needs to be able to hold up in a public space that’s accessed by the public. And there’s definitely sustainable materials that can do that, but it’s not what it is currently being done.”</i> (Interview 14)
3. Politics and Governance	8/16	<ul style="list-style-type: none"> - There is a clear lack of incentivisation offered by the government, which could have significant implications to the development industry and the implementation of more sustainable outcomes. - Policy and legislation have a fundamental role in encouraging sustainable change and can directly impact on building materials utilised for development. - Bureaucracy can constrain project outcomes and policy 	<i>“Council conditions certain approvals to have a sustainability element in it, but then there might be some developers or builders that try and manage those particular conditions out of the approval package.”</i> (Interview 6 & 7) <i>“Who’s providing incentive for people to think about it. It probably goes back into legislative requirements.”</i> (Interview 11) <i>“...the commercial development sector for example, or other areas aren’t upholding greater sustainability practices and obviously the Olympics is a classic</i>

BRISBANE'S TRANSITION TO A CIRCULAR CITY

		<p>change and result in major barriers to sustainability.</p> <ul style="list-style-type: none"> - Trade-offs have been recognised in political decision-making, with sustainability currently seen as a trade-off for housing supply. 	<p><i>example of that, right?" "We are trading off on things like design, things like sustainability and it's really difficult from a theoretical point of view to sit there and make those trade-offs." (Interview 13)</i></p> <p><i>"Councillors have power and can be 'massive barriers'" (Interview 15 & 16)</i></p>
4. Time	6/16	<ul style="list-style-type: none"> - Project timeframes hold major power in decision-making and related costs, leading to trade-offs. - Delays for building materials or project delivery can result in choosing more reliable or efficiently produced materials. - It can take time to change people's values and implement new alternatives for building materials. 	<p><i>"How can we sort of see the developers striving for the right outcomes and solutions and, as a result, let's try and get this moving quicker for them, which ultimately has inherent cost benefits, right cost savings." (Interview 4) "...the time that it takes to get that understanding that time and investment, those two go hand in hand." (Interview 8) "Designs or like philosophies, it takes time to develop properly and then make a standardised approach, so it's easy to implement." (Interview 11)</i></p>
5. Education	5/16	<ul style="list-style-type: none"> - Changing the traditional values in the industry requires education. - There remains a knowledge gap in the industry, specifically with clients and developers who may require additional education on new design alternatives. - A client relationship can have a key role in facilitating different outcomes for the project design. 	<p><i>"We've got to bring the client on board, so the way we bring clients on board, we educate them right from the beginning." (Interview 1)</i></p> <p><i>"I think tradition as much as anything, people don't like change. They like to do what they know. Particularly builders, because these builders have been in the industry for many years and they're used to build in concrete, you know, reinforced concrete frame buildings." (Interview 10) "More understanding of knowledge and obviously doing more projects brings that, but trying to educate clients with that knowledge that you sort of need time to learn and time to implement on a project very early. Mass timber is something that if a client's not looking at from day one it won't stack up once they get past a certain point of a project." (Interview 8)</i></p>
6. Risk and Uncertainty	5/16	<ul style="list-style-type: none"> - People's previous experiences force reliable 	<p><i>"...in the sustainable development space, there is a whole range of</i></p>

BRISBANE'S TRANSITION TO A CIRCULAR CITY

<ul style="list-style-type: none"> and less risky development choices. - Clients and developers need to see early adopters to have positive perception of change, new technologies etc. - Decision-making inherently can go one way or the other and people will generally follow more certainty and less risky outcomes. 	<p><i>emerging technologies that can be applied to developments, but it comes down to the question, do they want to be an early adopter or do they want to really wait until that technology is proven and cost effective before they take it up?"</i> (Interview 4) <i>"They still need to be built, designed and built correctly, but the lack of timber products projects that are out there at the moment brings uncertainty."</i> (Interview 8) <i>"I think that pre-existing perceptions of what something is and...like we've worked on or seen projects where you can make all your best decisions on the ground and then the maintenance team that it goes over to don't understand that."</i> (Interview 15 & 16)</p>
--	---

5.1.1 Cost

The most frequently identified barrier by the participants during the interview process was the costs associated with bio-based building materials within the development industry. Project viability has substantial influence in the decision-making of design from a budget and profitability perspective. This is one of the principal factors for clients and developers when proceeding with their projects. It can determine whether the projects can accommodate more sustainable building materials as part of the design or continue with the cheaper, traditional options such as steel and concrete. Many interviewees discussed their experiences within the development industry and reinforced the common theme of cost having major implications to building outcomes, creating barriers for high-quality, sustainable developments.

While cost will continue to be a key barrier in the development industry now and into the future, there is opportunity for change and, as identified by Interviewee 5, Brisbane is yet to find that balance between cost, design, and materiality. This presents an opportunity for the industry to seek other means to manoeuvre around this key barrier and to strive for more cost-effective processes.

5.1.2 Materials and Supply

Materials and supply have been at the forefront of Brisbane development in recent times following the severe impacts of the COVID pandemic. Brisbane has seen extreme service shortages and a lack of material availability in the development industry, resulting in this interconnectedness with costs. Brisbane's construction sector has seen numerous development projects go under leaving construction companies bankrupt and the industry in a major crisis. The cost of building materials such as timber, steel, and concrete began to exponentially increase, forcing considerable decreases in project profitability and viability. Materials and supply go hand in hand with costs as key barriers in the development industry. Group interview 6 & 7, who had a combined 17 years of planning experience in

BRISBANE'S TRANSITION TO A CIRCULAR CITY

the industry, verified the difficulties faced, specifically with service and materials costs. Their valuable insight is reiterated below:

“As soon as construction becomes more expensive it gets harder to achieve and there's been several examples within Brisbane, particularly where it's proven to be more expensive and more costly to actually refurbish or reuse materials rather than starting from scratch” (Interview 6 & 7).

As noted during the interview process, supply chains and service costs play a key role in transitioning to processes of circularity. Should refurbishing or reusing materials as part of the construction process become more expensive, clients and developers tend to go with another, cheaper option to make their projects more viable and stay within budget.

5.1.3 Politics and Governance

Another barrier within the development industry that can have significant implications on the implementation of sustainable design principles is politics and governance. This association can be attributed to power and decision-making, which can dictate the way in which new technologies and sustainable elements are integrated into the industry. Several resulting consequences have been identified in the interviews as a result of institutional barriers, including the lack of incentivisation, policy and legislative restrictions, bureaucracy, and trade-offs. Politics and governance were identified as a concern for the progression of sustainability and circularity within Brisbane, particularly with the upcoming Brisbane 2032 Olympic and Paralympic Games. Interviewee 13, a State Government Planning Manager, had recognised the difficulties in delivering more sustainable designs, with housing taking precedence over other matters such as sustainability. These trade-offs can be common problems for governing bodies, especially when political elections are approaching.

In Brisbane, the government have the ability to introduce and effectively incentivise sustainable measures to improve circularity within the development industry, yet this influence can also prevent sustainable progression. In these cases, there may be a need for societal pressures to force legislative changes to uphold greater sustainability practices.

5.1.4 Time

Time is a critical consideration for projects, development, and implementation and can therefore be a barrier for changing standards within the industry. Specifically, time has the potential to affect development outcomes for clients and developers. It can also impact on the implementation of emerging technologies, philosophies, and new values. For example, during the COVID pandemic the Brisbane market was hit with augmented costs for materials, which saw substantial delays for projects. These time delays had major repercussions for these projects and made it extremely difficult to estimate material costs, resulting in abandoned construction and insolvencies. Interviewee 4 considered time to also be a possible opportunity to positively influence clients and developers with improvements in the design and implementation of projects.

Expediting timeframes for clients and developers during stages of the planning process may help to facilitate the earlier implementation of sustainable development within a project. Strict timeframes, while sometimes necessary, can result in poor and rushed outcomes for the community and the city, limiting the possibilities to introduce sustainable designs.

BRISBANE'S TRANSITION TO A CIRCULAR CITY

5.1.5 Education

Education can be recognised as both a barrier and an opportunity when seeking changes to the development industry. A lack of education and awareness prevents relevant stakeholders from advocating for new and innovative pathways that can benefit conventional practices. If stakeholders are well-informed on opportunities in the industry, such as bio-based building materials, they can look past the short term and understand that these changes can result in substantial savings or long-term benefits for both the developers and future occupants.

Education was deemed to have a significant influence in the utilisation of alternative bio-based building materials and sustainable design within developments. The data demonstrates that there remains a knowledge gap in the industry, with clients not knowing or understanding the long-term benefits that can come from adopting new technologies or changing traditional preferences. The interviewees suggested that establishing trust with the client can be a determining factor in delivering positive change to project outcomes. Nonetheless, the lack of knowledge in the development industry is evident, particularly when more influxes of 'mum' and 'dad' developers enter the market in the hope of being opportunistic. Ultimately, this knowledge gap prevents the application of sustainable development principles and a potential shift away from the current linear system in place.

5.1.6 Risk and Uncertainty

Risk and uncertainty are seen as monumental barriers for the industry in the last few decades, with emerging technologies, new bio-based building materials, and energy efficient designs still not being standardised in the market. The energy consumption of buildings has been continually increasing, accounting for a significant percentage of global CO₂ emissions. However, despite the ongoing IPCC and UN reports documenting the inevitable failure in achieving GHG and SDG targets, markets are persisting with non-renewable resources and energy intense practices within the development industry. The interview data has indicated that Brisbane is following this market trend, continuing with non-renewable options, such as steel and concrete, instead of opting for bio-based building materials such as wood, hemp or bamboo. Interviewee 4, a Queensland Environment manager with 17 years' industry experience, noted the lack of adoption of emerging technologies and how it is preventing positive change.

This can be attributed to a perception or notion to stick with what works, regardless of the environmental consequences. Interviewee 10 reinforced this attitude when referring to the traditional values of people and how they are not in search of change, with builders being a prime example. Should this trend continue, the implementation of bio-based building materials will be adversely impacted and result in ongoing uncertainty within the development industry.

5.2 Key Opportunities of Bio-Based Building Materials in Brisbane's Development Industry

While the barriers explored remain evident within the development industry, new and emerging opportunities can progress the functionality of the sector and facilitate this much-needed shift towards renewable resources. In order to demonstrate how these opportunities can advance building and construction, advocacy and implementation are essential.

Opportunities that directly respond to research sub-questions 1 and 2 have been identified, with the results considering bio-based building materials and mass timber products as potential approaches to improving sustainability in Brisbane. Numerous key opportunities were identified within the empirical data collection and echoed throughout each interview, illustrated in Table 5. Specifically, six key opportunities were categorised based on

BRISBANE'S TRANSITION TO A CIRCULAR CITY

frequency in interviews, providing notable results for most common themes. Solutions and recommendations were analysed from the available transcripts, with further interview excerpts presented for transparency.

Table 5: Key Opportunities Identified in the Interview Process

Identified Opportunities	Frequency in Interviews	Summary	Excerpts from the Interviewees
1. Education and Awareness	12/16	<ul style="list-style-type: none"> - The development industry requires more actors to pilot these new and innovative pathways. - The role of leaders and key figures in the industry is crucial in capitalise on new opportunities. - The ability to promote and advocate for emerging technologies will go a long way in changing the traditional structures of a city. - Re-educating is a much needed process to demonstrate that there are better opportunities. 	<p><i>"We need to create the space for innovation and I actually think the biggest opportunity is piloting, testing and trialling...because everyone hates it until they can see it." (Interview 15 & 16) "...we need leaders to be aware of what the opportunities are and what sustainability is and how it benefits the whole world and not just them." (Interview 12) "...we need to be able to work with the industry to promote where it's already occurring, and it didn't have a crazy effect on cost and it was in the long run cheaper. I think we have a role to play to like, showcase those exemplar developments that did use sustainable materials, were constructed ethically, and it isn't always just the cheap and dirty option that should be highlighted." (Interview 13) "...re-educating people and changing the value system about what we actually know is better" (Interview 9)</i></p>
2. Technological Advancements	12/16	<ul style="list-style-type: none"> - The emergence of technological advancements, such as bio-based building materials, requires early adoption. - Bio-based building materials have shown that there are sustainable benefits to be recognised. - The use of carbon measuring tools are becoming more apparent in businesses. 	<p><i>"... people are becoming more aware now of sustainability and so they're looking more into their houses, getting more efficient devices, such as lighting." (Interview 1) "...in the sustainable development space, there is a whole range of emerging technologies that can be applied to developments, but it comes down to the question, do they want to be an early adopter or do they want to really wait until that technology is proven and cost effective before they take it up?" (Interview 4) "Those options are out there on the market. They do cost a bit more,</i></p>

BRISBANE'S TRANSITION TO A CIRCULAR CITY

		<ul style="list-style-type: none"> - New off-site development opportunities are being integrated in buildings, such as modular structures. 	<p><i>but there's a big push towards that. We rely on those suppliers to come to us and present where they're going...Thankfully that particular industry is in competition with itself with some targets for where those businesses want to get in terms of a carbon footprint." (Interview 8)</i></p>
3. Policy Implementation	8/16	<ul style="list-style-type: none"> - Incentivisation is an opportunity that must be realised to enable greater push for sustainable designs. - A top-down approach is necessary for recommending new sustainable policies. - New policy and legislative requirements for sustainability practices are required and should become mandatory. 	<p><i>"With this lack of incentivization, then obviously developers are not going to follow through with more sustainable designs because it'll cost them more." (Interview 12)</i></p> <p><i>"It has to start from the top down in my opinion. Like your planning schemes need to be written in a way that strives for that outcome." (Interview 5) "Our policies and standards influence decision making in terms of how we deliver and think of your bio based materials, such as mass timber". (Interview 9) "Having some more codes set within the policy will allow for facilitating more sustainable outcomes that will benefit Brisbane long term." (Interview 2 & 3)</i></p>
4. Circular Economy and Life Cycle Assessment (LCA)	7/16	<ul style="list-style-type: none"> - Building life must be considered when transitioning to sustainable building practices. - Reusing and recycling materials is the first stages to transitioning to a circular economy. - Small-scale companies repurposing excess construction materials, such as Five Mile Radius, demonstrate the willingness to change to circular systems. 	<p><i>"The industry and the whole energy carbon transition pieces is actually doing itself a massive disservice by not getting in front of these life cycle conversations." "Don't get me wrong, it's not something that is just pushed to the side, but maybe more could be done to get that word out there from a publicly facing perspective, because at the end of the day, it's going to help drive that transition of which you know, materials come into it." (Interview 4) "So it's sort of suggesting, yes, there's the decommissioning piece, but what it's actually doing, and I think this applies to any development, whether it's big infrastructure, renewables, or urban development, is start to think around what is the life cycle of those materials. Do</i></p>

BRISBANE'S TRANSITION TO A CIRCULAR CITY

			<p><i>they end up in landfill, that completion, or do they have a second life either as reuse or recycled?" (Interview 8) "Though it's kind of small scale, but there's some really cool little companies that are incorporating different methods of reuse for different construction materials that are currently on site. But say if there's like an excess amount of concrete on site, they'll actually be the company that goes and diverts the concrete rather than it going to landfill." (Interview 14)</i></p>
5. Certifications and Ratings	6/16	<ul style="list-style-type: none"> - Green-star ratings improve marketing opportunities in development and are becoming more sought after. - Infrastructure Sustainability Council of Australia (ISCA) ratings are another applied tool in helping to drive sustainability. 	<p><i>"You've got a lot of organisations, like green-star neighbours, all those sustainable, you know, guidelines or tick the boxes or certificates which actually are good things that that clients get on board because then they've got something to market." (Interview 1)</i></p> <p><i>"Some of the projects that I've been involved in, I've done a bit of TMR (Transport and Main Roads) work on big road infrastructure projects and that will use the ISCA framework and the ISCA ratings to help drive those projects." (Interview 2 & 3)</i></p> <p><i>"In Brisbane, a lot of the new kind of green tools, Green star rating, things like that for commercial development are picking up in local government planning schemes." (Interview 13)</i></p>
6. Production	4/16	<ul style="list-style-type: none"> - Sourcing of materials, both local and international, can play a significant role in production opportunities. - There are opportunities for increased production practices in Australia, e.g. forestry practices for timber stock, which can have positive implications to the industry. 	<p><i>"The thing is at the moment there was a lot of hardwood timber, which is actually not a sustainable timber. So now it's all going back to pine, which is a very much Nordic kind of scenario. So, there is not enough softwood production to get the demand for mass timber construction." (Interview 1)</i></p> <p><i>"Australia is starting to make headway with 2 plants down south that now are starting to produce mass timber, with the third coming online, but this particular project is</i></p>

using timber from Italy and bringing it from overseas, which in its own right obviously has some impact to the carbon and sustainability side of it.” (Interview 8)

5.2.1 Education and Awareness

One of the most important opportunities identified in the interviews and relevant literature is the effectiveness of education and awareness. This opportunity can be introduced within planning processes, client or customer interactions, and initiated within the education and training sector. However, it is industry leaders who have a major role in implementing change and re-educating an already conventional system. This was evident in a statement from Interviewee 12, which acknowledged that “...we need leaders to be aware of what the opportunities are and what sustainability is and how it benefits the whole world and not just them.” There were other effective strategies mentioned in interviews 15 and 16, identifying the use of piloting as a technique to normalise new sustainable designs.

Education and awareness were the most discussed opportunity and recognised as the primary strategy to enhance greater knowledge within the development industry. Some approaches discussed involved showcasing of exemplar developments that were designed with a focus on sustainability rather than the projects that lack these innovations. These types of approaches would enable further discussion within the industry, allowing sustainability to inform and promote this change.

5.2.2 Technological Advancements

Technological advancements and efficiencies have been emerging in the development industry with many new and sustainable building materials and processes available, presenting clear opportunities for the sector that can lead to major positive implications for Brisbane’s sustainability targets. Companies are now looking into carbon measuring tools for buildings and moving towards new construction practices through modular development, which can be built off-site more efficiently. Bio-based building materials, such as mass timber, is another emerging pathway becoming more recognised in Brisbane buildings with timber material construction coming back to the forefront. However, as evident in the excerpts from the interviews of Table 5, it is about the adoption of these new technologies and whether developers are prepared to support and showcase this transition to achieve sustainable and innovative goals.

Figure 8 and Figure 9 overleaf illustrate two examples of mass timber development within Brisbane. Figure 8 involves a fully timber designed dwelling house, maintaining the ‘Queenslander’ character still depicted in suburban streets of Brisbane. Figure 9 depicts the Monterey development, the first cross-laminated timber (CLT) residential high-rise building in Brisbane. Built in 2021 and engineered by Aurecon, the Monterey development is Australia’s tallest engineered timber residential tower. The mass timber design was primarily chosen due to the light-weight nature, siting above an underground freeway tunnel, along with the aesthetics, speed of construction, and sustainable benefits of the bio-based building material. These modern architectural examples demonstrate the potential of technological advancements on the development industry and the benefits they can achieve.

BRISBANE'S TRANSITION TO A CIRCULAR CITY



Figure 8: Mass Timber Dwelling House in Suburban Brisbane (Morgan, 2024)



Figure 9: The Monterey – First CLT High-Rise Residential Building in Brisbane (Morgan, 2024)

BRISBANE'S TRANSITION TO A CIRCULAR CITY

5.2.3 Policy Implementation

Policy and legislation present an opportunity to influence sustainable practices and guide development within the industry. With key strategic policies such as the Brisbane City Plan 2014 and the South East Queensland Regional Plan 2023, growth and development is heavily subject to strict code requirements which impact how buildings and projects are delivered. The interviewees supported the significance of policy making and the top-down approach needed to facilitate the increase in sustainable designs.

Incentivisation of sustainable development was one frequently mentioned aspect of policy implementation that could effectively change the pathways for developers. The implementation of incentives by regulators and policymakers can allow developers to manage costs more efficiently by integrating sustainable designs early within the planning process. This was reinforced in interview 12 where the interviewee outlined that developers will not follow through with sustainable and innovative goals when it will cost them more, resulting in problems with project viability. Interviewee 5 noted how policy can benefit regions, referencing the New South Wales State Government, which have implemented climate change policies as part of the assessment of development applications in order to strive for further change in building practices. Adopting this approach in Brisbane would create positive movements in the development industry.

5.2.4 Circular Economy and LCA

The systems of a circular economy and the LCA of building materials have been investigated by sustainability focused companies internationally, leading to benefits in the transition away from non-renewable resources. In Brisbane specifically, the interviews have recognised that there is still a long way to go before these 'life cycle conversations' turn into action within the development industry. The building life of structures have always been a consideration when projects are executed on-site, and yet, the decommissioning process of these developments has generally been dismissed. The resulting interview data shows that the decommissioning of buildings is an overseen opportunity that can have significant implications to the industry and result in cost savings, recycling and reusing of materials, and an improvement to the way in which the built environment system operates.

As identified from interviewees, there are examples of small companies that have been established to assist in this decommissioning process by attending to sites and extracting the excess materials that would otherwise become landfill. Five Mile Radius, who work with low carbon bio-based building materials such as timbers, earth and stone as well as construction waste and salvaged materials were commonly referred in the interviews. *"Both our architecture and product work aims to limit the extraction of non-renewable resources while ensuring we consider the lifecycle of each material we use"* (Five Mile Radius, N.D, p.1). This and other companies that focus on LCA help facilitate a 'second life' for building materials, which play a crucial role in helping Brisbane transition towards a circular city that recycle and reuse materials within the development industry.

5.2.5 Certifications and Ratings

As the importance of sustainability has become globally recognised through the mounting pressures of climate change and resource consumption, new tools for sustainable design have been embedded into the development industry to encourage innovation and building performance. In Brisbane, there have been a number of sustainability certifications and rating systems introduced that encourage new forms of development to be delivered into the market that meet people's changing values.

Green-star ratings and the ISCA, who have implemented an Infrastructure Sustainability (IS) rating scheme for planning, design, construction and operations of infrastructure assets and portfolios, are two key sustainability tools that are utilised in modern development. Figure 10 overleaf exhibits an exemplar mass timber office building for

BRISBANE'S TRANSITION TO A CIRCULAR CITY

Aurecon, built in 2018, which achieved a 6 Star Green Star design, the highest sustainable rating a building can achieve, through the incorporation of rooftop solar, rainwater capture, and a 74% reduction of embodied carbon, 46% reduction in energy and 29% reduction in potable water consumption (Sustainability Awards, 2024). This building demonstrates the principles of circular economy and is a key example of what the development industry can produce to achieve not only lower carbon footprints but also high quality, sustainable outcomes for Brisbane.

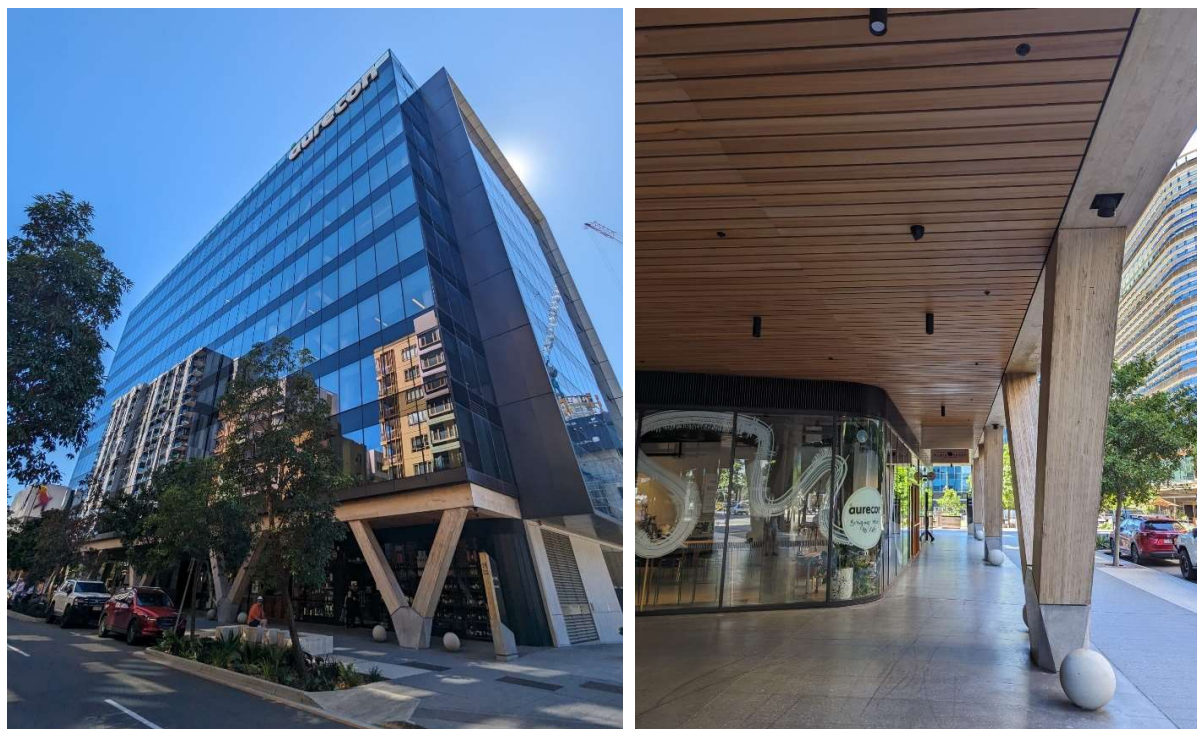


Figure 10: Aurecon Office – First Mass Timber Commercial Building in Brisbane (Morgan, 2024)

5.2.6 Production

Production and sourcing of building materials interconnects with a number of barriers and opportunities, upholding specific implications to the development industry. The building material market has seen major fluctuations in pricing and availability since the COVID-19 pandemic, due to factors including importation and exportation, supply, and production. Emmett (2022) found that most contractors were impacted by logistical constraints and time delays, waiting for the arrival of materials, which resulted in delays to the project schedule, or would be forced to pay premium costs for locally sourced materials.

Multiple interviewees discussed the lack of soft wood forestry or mass timber manufacturers in Australia, noting the influence that international markets have on the construction sector, resulting in importing timber from new overseas suppliers. This change to overseas companies will create a reliance on international suppliers, which would not only impact local providers due to the competition but would also increase the long-distance transportation, meaning significant CO₂ emissions. Therefore, there remains an opportunity to expand the forestry practices for timber stock and support mass timber manufacturers within Australia to facilitate more efficient and sustainable project outcomes that can still achieve budgets and timeframes. An expansion of locally sourced building materials will inherently strengthen a transition towards a more circular economy, resulting in reduced carbon emissions from transportation distances, increased availability of the supply chain, high-quality local materials, and local economic growth.

5.3 Identified Stakeholders and their Role in this Sustainable Transition

Stakeholders and representatives of the development industry have the power to radically influence the barriers and opportunities of building materials and, as such, can play a fundamental role in positively advocating a sustainable transition towards more bio-based alternatives. A review of each stakeholder's influence on these barriers and opportunities identified in the results will allow for a greater understanding between these linkages and the resources at their disposal, specifically focusing on addressing sub-question 3 of this study. A number of stakeholders were identified in the interview data that have the capability to significantly influence the development industry.

Government, whether Local, State or Federal, is one of the most significant stakeholders in this sustainable development transition due to the available resources and authority to enable change. It was identified in the results that the Government can heavily influence the barriers of politics and governance and time, dictating the timeframes for development approvals and forcing trade-offs that may favour political elections or seek economic gain from large-scale events, such as the Brisbane 2032 Olympic and Paralympic Games. The Government is more closely linked with the opportunity of policy implementation and have the capability to facilitate strategic policy changes, incentivisation, or expediting project timeframes, demonstrating their importance and power as a stakeholder in this sustainable transition.

Other stakeholders including architects, urban planners, engineers, builders, and quantity surveyors can support this transition through using their position to advocate for sustainable practices within the various stages of the development process. Whilst these stakeholders may lack the power and finance to implement such changes themselves, they can utilise their networks, experiences, and insight to drive opportunities such as education and awareness, technological advancements, circular economy and LCA, and certifications and ratings. On the other hand, clients and developers do have power and financial means that allow them to make critical development decision, however, it was identified that the key barrier of education can negatively influence these decisions and inhibit innovative design, leading to unfortunate trade-offs for projects. Another key and often overlooked catalyst is the community and associated politicians, such as Councillors. While they have little power individually, these particular stakeholders can cause radical decisions in unity, influencing the key barrier of politics and governance and forcing changes in the development industry. While evidently not all stakeholders have the same level of power or influence, they all have opportunities to strive for change within the development industry and to contribute to a more sustainable future for Brisbane.

6.0 Discussion

6.1 Synthesis of Research and Results

To compare and contrast the theoretical framework with the resulting barriers and opportunities of the interview process, a synthesis of the Circular Economy Framework by Elia et al (2017) has been developed using the case study research from Brisbane. Figure 11 presents the findings of the six main barriers and opportunities identified and integrates these with the circular monitoring processes of the Circular Economy Framework. The results of this research have adapted the framework to be specific to the utilisation of bio-based building materials in a circular process for Brisbane. A number of notable links between some barriers and opportunities were found that can influence their magnitude and effectiveness while also having planning implications as to how the principles of circularity are implemented. These links have been described as interconnected aspects.

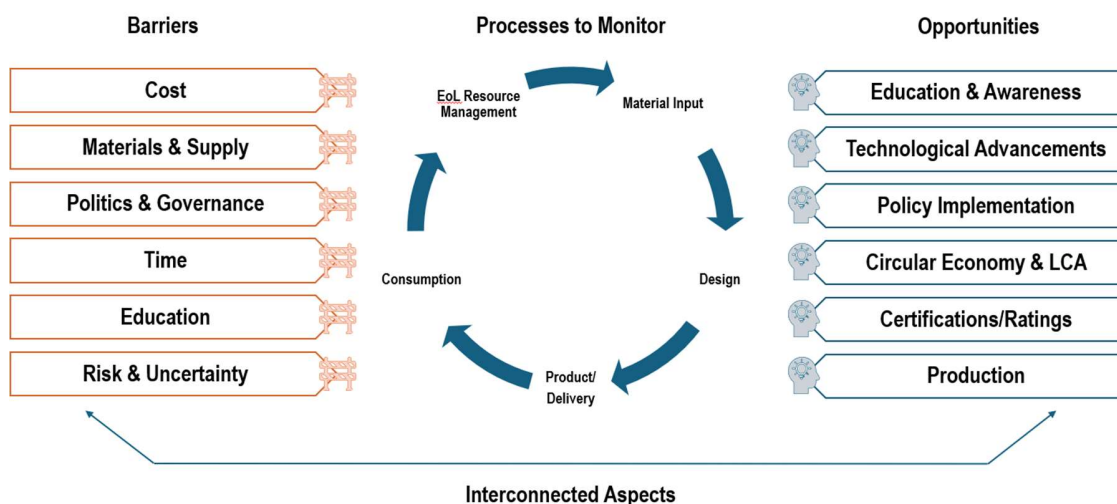


Figure 11: A Synthesis of the Theoretical Framework (Morgan, 2024)

The findings showed that these interconnected aspects are distinguishable within each of the key barriers. For example, the cost associated to acquire bio-based building materials is interrelated with the materials and supply, which is subsequently impacted by time delays, as evident during the COVID pandemic. Furthermore, the lack of education surrounding these sustainable materials was also connected with risk and uncertainty, as it was noted that developers and clients would be unlikely to adopt bio-based building materials until there is clear evidence that these alternatives work in the industry. There were also surprising linkages in between both barriers and opportunities that had implications to the use of bio-based building materials Brisbane's development industry. It is apparent that politics and governance can have a major influence on policy implementation, with government agencies or political leaders having the power to dictate new policy measures which are able to increase the adoption of sustainable designs. Production can have inherent impacts to materials and supply, as demonstrated by the lack of mass timber manufacturers in Australia which has led to the shortage of mass timber developments. Lastly, the role of key stakeholders was influential in this shift toward a circular city as they have the capability to create these potential barriers and opportunities. Overall, the synthesis of the chosen theoretical framework and the research results demonstrate the linkages evident to implementing circularity within the case study city of Brisbane, outlining the interconnected barriers and opportunities for bio-based building materials in the development industry.

BRISBANE'S TRANSITION TO A CIRCULAR CITY

6.2 Response to the Research Questions

This study has reviewed a range of literature applicable to understanding the background of sustainable development and assessing the barriers and opportunities of bio-based building materials and the circular economy concept. The Circular Economy Framework from Elia et al (2017) has been an effective framework to evaluate and instil the circular processes of reducing, reusing, and reproducing to address the knowledge gap in Brisbane's development industry and promote a sustainable transition away from the current linear system. The literature suggests that the 'circular city' model is a measurable and achievable framework, which has already been implemented in many European cities. Whilst it has been acknowledged that every country, city, and region have different processes that may limit the effectiveness of this approach, there is evidence that show the circular economy can solve sustainability challenges. As established by the results of this study, the barriers and opportunities of bio-based building materials require further consideration when applying the circular city model, and these are determined to be key factors in Brisbane's shift to a circular economy. The interview data has therefore been necessary in responding to the overarching research question and sub-questions.

Connecting each of these concepts within the sub-questions enabled theorisation of the pathways for transitioning a city from the traditional linear economy to a system of circularity. Understanding the benefits and limitations of these concepts reinforces the effectiveness of this study and contributes to narrowing the overarching research question. Figure 12 summarises general responses to the sub-questions, also discussed throughout this study.

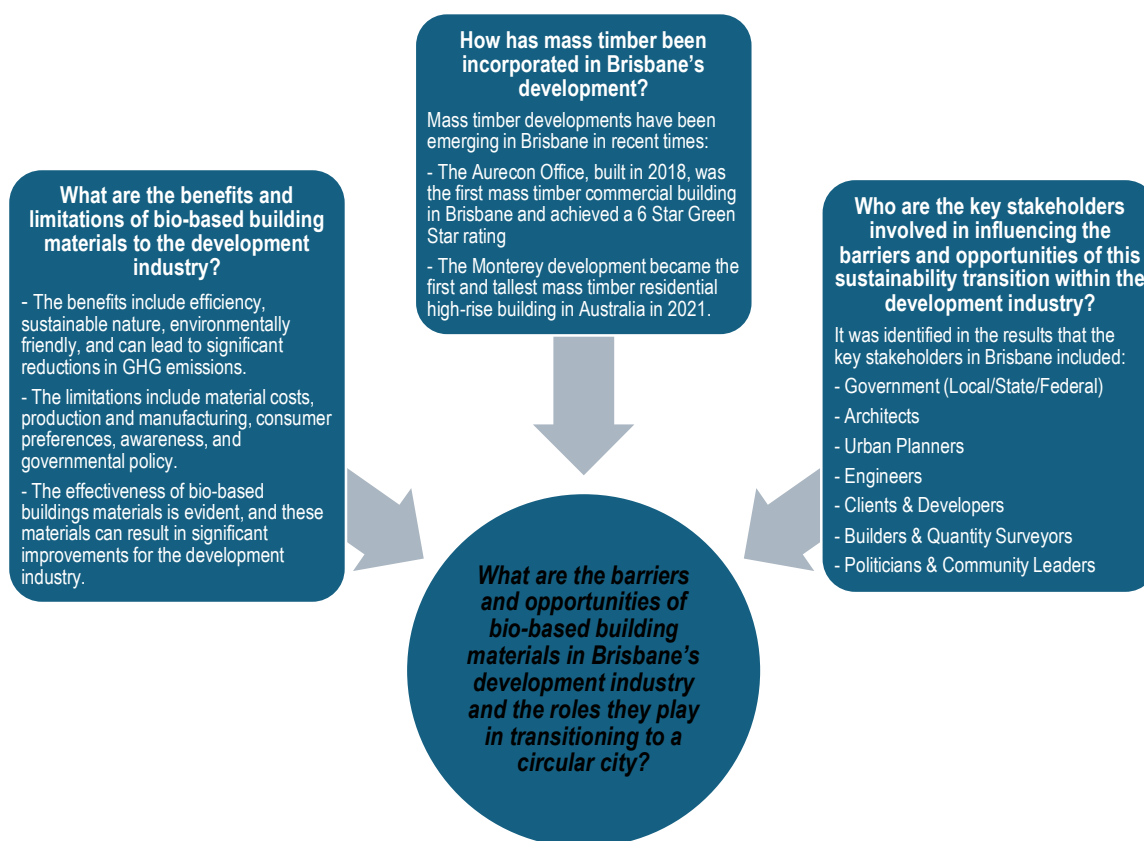


Figure 12: Responding to Research Questions

6.3 Planning Recommendations from Results

The results have uncovered the main barriers and opportunities of bio-based building materials within Brisbane's development industry, noting the influence of key stakeholders and signifying the potential for planning recommendations to support the transition to a circular city. As established in the interview data, the identified opportunities available to the industry suggest that these factors can become counter measures to the barriers that are preventing the implementation of necessary sustainable options. If Brisbane is to achieve its goal of delivering a vision of a clean, green, and sustainable city (BCC, 2024), change in the industry is essential.

There have been several planning recommendations recognised from the results that correspond to the barriers and opportunities of bio-based building materials. The concept of changing traditional values and educating the industry is one recommendation that should be explored. While this can be a challenging and timely process, it was seen that the role of piloting new technological advancements, such as bio-based building materials, can result in increased awareness of the benefits that can be exhibited. This was evident through the promotion of exemplar developments in the industry, with the first engineered mass timber commercial building for Aurecon in 2018 paving the way for the Monterey, a mass timber high-rise residential building, which followed in 2021. Other Australian cities are following this emergence of mass timber design, with a 50-storey mass timber mixed use development recently approved in Perth. Piloting paired with the implementation of other opportunities would directly strengthen this transition toward a sustainable, circular city. The statutory adoption of planning incentives, such as reductions in infrastructure charges, and strategic policy initiatives, such as mandatory green star ratings for large-scale developments, can further this momentum of sustainable building materials and system shifts. In addition, the expediting of planning assessment, approvals, and post-approval works (e.g. plan sealing) can enable smoother, more efficient processes for clients and developers, securing specific time/cost benefits and having corresponding effects to the market and built form outcomes.

Noting these planning recommendations, momentum from key stakeholders in the development industry is needed as their advocacy for these changes holds significantly more value than 'word of mouth'. Government and industry leaders such as architects, urban planners, and builders, are the main stakeholders that need to be involved in facilitating the movement of these opportunities and contributing to this push for Brisbane to become a circular city. Acknowledging revolutionary examples occurring in modern society can greatly assist in shifting perceptions and values and can be expanded to be globally recognised solutions for facilitating this much-needed transition to sustainable systems.

7.0 Conclusion

7.1 Summary of Study

The objective of this study was to acquire prescriptive knowledge in order to provide a response to the overarching research question: ***What are the barriers and opportunities of bio-based building materials in Brisbane's development industry and the roles they play in transitioning to a circular city?***

Through understanding the key concepts (sustainability and sustainable development, the circular economy, and bio-based buildings materials) and delving into the case study location of Brisbane, the data collected enabled the identification of key barriers and opportunities of bio-based building materials that remain evident within the development industry. These results provided crucial understanding of the interconnecting factors that play fundamental roles in the urban growth of Brisbane, dictating the application of new and emerging technologies that can enhance the operational shift towards a more circular city. The research recognised that there remains an underutilisation of bio-based building materials within the development industry, demonstrating the lack of progress in facilitating this much-needed shift towards renewable resources. However, the use of mass timber is becoming trusted in the construction of large-scale buildings, which has indicated the importance of piloting, incentivisation, and policy implementation, proving there are still major opportunities to enhance the functionality of the sector in Brisbane to become more sustainable.

Application of this research into societal practices would advocate for sustainable development and promote further action into one of the most energy consuming sectors, effectively contributing to addressing the major challenges of climate change, population growth, and urbanisation. The utilisation of mass timber on many levels of construction, including in material combinations and off-site efficiencies, will support sustainable material use as well as product performance in an evolving economy. The social implications of this research can strengthen Brisbane's industry during this period of significant growth in line with the upcoming Brisbane 2032 Olympic and Paralympic Games and steer momentum into achieving global sustainability targets, such as the SDGs.

Lastly, the circular economy theory behind this research can have implications for strategic planning authorities, specifically policymakers and governmental agencies to facilitate the principles of circularity in Brisbane's planning system. The change from traditional linear systems can encourage further opportunities within the development industry and create more sustainable outcomes. Furthermore, broadening this implementation of the circular city concept to other national and international cities can be instrumental in realising the positive qualities and gauge its success.

7.2 Recommendations for Further Research

Based on these results and the considered benefits of a circular economy in reaching sustainability targets, further research in other international cities is recommended to obtain valuable insights and to help identify further barriers and opportunities in transitioning to a circular city. Additionally, other Australian cities would be well-suited for circular systems given the available resources and potential for renewable energy practices, which could significantly benefit from further research. Exerting influence on a global scale will support the drive in positive operational changes to overcome universal sustainable development targets and to safeguard Earth's natural systems for future generations.

8.0 Bibliography

- Agenzia europea dell'ambiente. (2016). *Circular Economy in Europe: developing the Knowledge Base*. Publications Office of the European Union.
- Baker, S. E., & Edwards, R. (2012). How many qualitative interviews is enough.
- Barbier, E. (1998). The concept of sustainable economic development. In *The Economics of Environment and Development* (pp. 1-21). Edward Elgar Publishing.
- Brisbane City Council (BCC). (2024a, February 15). *Brisbane. Clean, Green, Sustainable*. Retrieved February 8, 2024, from <https://www.brisbane.qld.gov.au/clean-and-green/brisbane-clean-green-sustainable>
- Brisbane City Council (BCC). (2024b, April 19). *Brisbane 2032 Olympic and Paralympic Games*. Retrieved May 12, 2024, from <https://www.brisbane.qld.gov.au/about-council/news-and-publications/brisbane-2032>
- Circular Cities Declaration (CCD). (2020). *Cities and the Circular Economy*. Retrieved May 16, 2024, from <https://circularcitiesdeclaration.eu/cities-and-the-circular-economy/what-is-a-circular-city#:~:text=A%20Circular%20City%20Definition%20%22A%20circular%20city%20is,collaboration%20with%20citizens%2C%20businesses%20and%20the%20research%20community.>
- Circular Cities Declaration (CCD). (2024). *CCD Report 2024*. Retrieved May 16, 2024, from <https://circularcitiesdeclaration.eu/about/ccd-report>
- Climate Change: The IPCC 1990 and 1992 Assessments — IPCC*. (n.d.). IPCC. <https://www.ipcc.ch/report/climate-change-the-ipcc-1990-and-1992-assessments/>
- Elia, V., Gnoni, M. G., & Tornese, F. (2017). Measuring circular economy strategies through index methods: A critical analysis. *Journal of cleaner production*, 142, 2741-2751.
- Emmett, T. (2020, April 22). *COVID-19 and the impact on Australian construction projects*. Turner & Townsend. Retrieved April 12, 2024, from <https://www.turnerandt Townsend.com/en/perspectives/covid-19-and-the-impact-on-australian-construction-projects/>
- Eric Baldwin. "Precht Designs Timber Skyscrapers with Modular Homes and Vertical Farming" 25 Feb 2019. ArchDaily. Accessed 7 Jun 2024. <<https://www.archdaily.com/912058/precht-designs-timber-skyscrapers-with-modular-homes-and-vertical-farming>> ISSN 0719-8884
- Evison, D. C., Kremer, P. D., & Guiver, J. (2018). Mass timber construction in Australia and New Zealand—Status, and economic and environmental influences on adoption. *Wood and Fiber Science*, 128-138.
- Five Mile Radius. (n.d.). *Five Mile Radius - About*. Retrieved April 14, 2024, from <https://www.fivemileradius.org/pages/about>
- Fleischmann, K. (2019). Design-led innovation and Circular Economy practices in regional Queensland. *Local Economy*, 34(4), 382-402.
- Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy—A new sustainability paradigm?. *Journal of cleaner production*, 143, 757-768.

BRISBANE'S TRANSITION TO A CIRCULAR CITY

- Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner production*, 114, 11-32.
- Global Alliance for Buildings and Construction (GlobalABC). (2020, December 16). *2020 GLOBAL STATUS REPORT FOR BUILDINGS AND CONSTRUCTION*. Retrieved February 20, 2024, from <https://globalabc.org/news/launched-2020-global-status-report-buildings-and-construction#:~:text=With%20the%20inclusion%20of%20emissions%20from%20the%20buildings,transport%20and%20other%20industry%20emissions%20relative%20to%20buildings.>
- Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field methods*, 18(1), 59-82.
- GQ Research. (2023, October 6). Greening Industries: The Bio-Based Materials Revolution. *GQ Research*. Retrieved May 8, 2024, from <https://gqresearch.com/blog-bio-based-materials-market/#:~:text=The%20Most%20Important%20Challenges%20in%20the%20Global%20Bio-Based,unaware%20of%20the%20advantages%20of%20bio-based%20materials.%20>
- Halog, A., Balanay, R., Anieke, S., & Yu, T. Y. (2021). Circular economy across Australia: taking stock of progress and lessons. *Circular economy and sustainability*, 1(1), 283-301.
- Hancock, T. (1993). Health, human development and the community ecosystem: three ecological models. *Health promotion international*, 8(1), 41-47.
- Hassan, M. (2024, March 25). *Limitations in research - Types, Examples and writing guide*. Retrieved May 20, 2024, from <https://researchmethod.net/limitations-in-research/>
- Hipp, J. R., Corcoran, J., Wickes, R., & Li, T. (2014). Examining the social porosity of environmental features on neighborhood sociability and attachment. *PloS one*, 9(1), e84544.
- International Finance Corporation (IFC). (2019, December 2). *Green Buildings: A Financial and Policy Blueprint for Emerging Markets*. Retrieved January 10, 2024, from <https://www.ifc.org/en/insights-reports/2019/green-buildings-report>
- Intergovernmental Panel on Climate Change (IPCC). (1992, June). *Climate Change: The IPCC 1990 and 1992 Assessments*. IPCC. Retrieved December 16, 2023, from <https://www.ipcc.ch/report/climate-change-the-ipcc-1990-and-1992-assessments/>
- Intergovernmental Panel on Climate Change (IPCC). (2022, February 28). *IPCC Sixth Assessment Report - Headline Statements from the Summary for Policymakers*. IPCC. Retrieved December 16, 2023, from <https://www.ipcc.ch/report/ar6/wg2/resources/spm-headline-statements/>
- Keena, N., Raugei, M., Lokko, M. L., Aly Etman, M., Achnani, V., Reck, B. K., & Dyson, A. (2022). A life-cycle approach to investigate the potential of novel biobased construction materials toward a circular built environment. *Energies*, 15(19), 7239.
- Knight, J. (2015). Anthropocene futures: People, resources and sustainability. *The Anthropocene Review*, 2(2), 152-158.
- Kremer, P. D., & Symmons, M. A. (2015). Mass timber construction as an alternative to concrete and steel in the Australia building industry: a PESTEL evaluation of the potential. *International Wood Products Journal*, 6(3), 138-147.
- MacArthur, E. (2013). Towards the circular economy. *Journal of Industrial Ecology*, 2(1), 23-44.

BRISBANE'S TRANSITION TO A CIRCULAR CITY

- MacCallum, D., Babb, C., & Curtis, C. (2019). *Doing research in urban and regional planning: Lessons in practical methods*. Routledge.
- Muriuki, G., Dowd, A. M., & Ashworth, P. (2016). Urban sustainability—a segmentation study of Greater Brisbane.
- Pacheco-Vega, B. R. (2018, September 28). *Writing theoretical frameworks, analytical frameworks and conceptual frameworks*. Retrieved December 18, 2023, from <http://www.raulpacheco.org/2018/09/writing-theoretical-frameworks-analytical-frameworks-and-conceptual-frameworks/>
- Petit-Boix, A., & Leipold, S. (2018). Circular economy in cities: Reviewing how environmental research aligns with local practices. *Journal of Cleaner Production*, 195, 1270-1281.
- Pomponi, F., & Moncaster, A. (2017). A theoretical framework for circular economy research in the built environment. *Building Information Modelling, Building Performance, Design and Smart Construction*, 31-44.
- Prendeville, S., Cherim, E., & Bocken, N. (2018). Circular cities: Mapping six cities in transition. *Environmental innovation and societal transitions*, 26, 171-194.
- Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: in search of conceptual origins. *Sustainability science*, 14, 681-695.
- PwC Australia. (2021, March). *Building a more circular Australia*. Retrieved February 11, 2024, from <https://www.pwc.com.au/environment-social-governance/building-a-more-circular-australia.html>
- Shackleton, S., Bezerra, J. C., Cockburn, J., Reed, M. G., & Abu, R. (2021). Interviews and surveys. In *The Routledge Handbook of Research Methods for Social-Ecological Systems* (pp. 107-118). Routledge.
- Streefkerk, R. (2019, April 25). *Transcribing an Interview | 5 Steps & Transcription Software*. Retrieved February 4, 2024, from <https://www.scribbr.com/methodology/transcribe-interview/>
- Suárez-Eiroa, B., Fernández, E., Méndez-Martínez, G., & Soto-Oñate, D. (2019). Operational principles of circular economy for sustainable development: Linking theory and practice. *Journal of cleaner production*, 214, 952-961.
- Sustainability Awards. (n.d.). *25 King, Brisbane - Sustainability Awards - Building a better future through design excellence*. Retrieved May 20, 2024, from <https://www.sustainablebuildingawards.com.au/commercial-architecture-large-2020/25-king-brisbane/>
- Suttie, E., Hill, C., Sandin, G., Kutnar, A., Ganne-Chédeville, C., Lowres, F., & Dias, A. C. (2017). Environmental assessment of bio-based building materials. In *Performance of bio-based building materials* (pp. 547-591). Woodhead Publishing.
- Tabet, T. (2022, April 20). *World's Tallest Timber Tower Planned for Perth*. The Urban Developer. Retrieved May 6, 2024, from <https://www.theurbandevolver.com/articles/worlds-tallest-timber-tower-grange-development-south-perth>
- United Nations. (n.d.). *THE 17 GOALS | Sustainable Development*. Retrieved December 8, 2023, from <https://sdgs.un.org/goals>
- United Nations. (2023a). *Goal 11 | Department of Economic and Social Affairs*. Retrieved December 17, 2023, from https://sdgs.un.org/goals/goal11#progress_and_info

BRISBANE'S TRANSITION TO A CIRCULAR CITY

- United Nations. (2023b). *Goal 13 | Department of Economic and Social Affairs*. Retrieved December 17, 2023, from https://sdgs.un.org/goals/goal13#progress_and_info
- United Nations Human Settlements Programme (UN-Habitat). (2022). *World Cities Report 2022: Envisaging the future of Cities*. Retrieved February 8, 2024, from <https://unhabitat.org/wcr/>
- Wastling, T., Charnley, F., & Moreno, M. (2018). Design for circular behaviour: Considering users in a circular economy. *Sustainability*, 10(6), 1743.
- Wohlin, C. (2014, May). Guidelines for snowballing in systematic literature studies and a replication in software engineering. In *Proceedings of the 18th international conference on evaluation and assessment in software engineering* (pp. 1-10).
- World Commission on Environment and Development (WCED). (1987). *Our Common Future, From One Earth to One World*. Retrieved January 18, 2024, from <https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf>
- Yadav, M., & Agarwal, M. (2021). Biobased building materials for sustainable future: An overview. *Materials Today: Proceedings*, 43, 2895-2902.

9.0 Appendices

Appendix 1: Interview Guideline

Note: All interviews will be conducted in English and transcribed using Microsoft Teams.

Greeting: Thanks for your time today in joining me for this interview in relation to my master's thesis. It is great to have this opportunity to meet and discuss this topic that has become increasingly relevant in the development industry. Before I begin, I just wanted to check for your consent to record this interview via my mobile phone to enable suitable transcription methods. I would also like to emphasise that all information provided will be treated confidentially and is purely for research purposes. Please note all interviewees will be anonymised in the results and thesis, unless requested otherwise. We will try to have this wrapped up in approximately 45 minutes as I understand how important your time is during this difficult period of public holidays around Easter.

Introduce topic: As previously indicated in our message exchanges, I am currently working on my master's thesis for the Spatial Planning degree at Utrecht University. The topic I have chosen is looking into building materials as an opportunity to become more sustainable and support a transition away from our linear system that relies on fossil fuels and non-renewable resources. Specifically, my overarching research question is:

What are the barriers and opportunities of bio-based building materials in Brisbane's development industry and the roles they play in transitioning to a circular city?

In this regard, the circular city concept refers to this transition of a linear economy to a circular economy which manages resources better and efficiently to become more sustainable. Sustainability, whilst broad and can incorporate many different areas, refers to the resources and design elements that can have positive impacts to reducing carbon emissions and global warming. I have chosen Brisbane as my case study location due to the city having a distinct opportunity during this period of substantial growth in line with the upcoming 2032 Olympic and Paralympic Games whilst also striving for a more sustainable economy.

Interview Questions

Note: Always stress that you need to hear from their experience not in general what the industry does...

1. Background of Interviewee (**Goal: Identify background information to understand relevance for research**)
 - a. Would you please confirm your name and the company you work at?
 - b. Can you explain what your role is at this company and its relevance within the development industry?
 - i. How many years of experience do you have in this industry?
2. Work Intent (**Goal: Identify the projects/work involved and sustainability intent**)
 - a. What type of projects/work does your company get involved with (scale, public/private, market type)?
 - b. Who do you engage or collaborate with in these projects (key stakeholders)?
 - c. What is the intended goal for your projects/work? Does sustainability have any importance?
3. Sustainable Development Measures (**Goal: Understand applicability in the development industry**)
 - a. To what extent is your company incorporating sustainability measures within your project design?
 - b. In your experience, what do you think are the barriers for sustainability and sustainable development designs within the development industry?

BRISBANE'S TRANSITION TO A CIRCULAR CITY

- c. What would be some opportunities to incorporate sustainable building materials in development?
 - i. Do you think bio-based materials, such as mass timber, could have a role in changing practices in the industry?
 - d. Since the recent introduction of mass timber, what barriers have you seen?
 - i. What opportunities has it created in the industry?
4. Policy Integration (**Goal: Understand the opportunities and barriers in existing policy**)
- a. When planning for projects, how much is determined or influenced by policy and regulation?
 - b. Have you encountered many sustainability requirements for projects based on the current policies?
 - c. What challenges are there when delivering sustainable outcomes in your projects?
 - d. What do you think could be better integrated in policy to facilitate more sustainable development?

Concluding Remarks: Before we finish this interview, I would like to ask how you believe we can participate in helping deliver more sustainable development within the building sector?

- Is there anything further you would like to add?
- Given the information in this interview, would you recommend anyone to participate in this study?
- Is there anything I can do better for my next interviews?

Thank you very much for your time here today and your valuable insight into Brisbane's development industry. Please let me know if you would like to stay updated on the results of this research and, should you have any further questions after this interview, you may contact me via phone or email.