

Waste Diversion and Reduction in a Green Office Building: A Social Practice Theory  
Lens

by  
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A thesis  
presented to the University Of Waterloo  
in fulfilment of the  
thesis requirement for the degree of  
Master of Environmental Studies  
in  
Sustainability Management

Waterloo, Ontario, Canada, 2023

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## Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

## Abstract

A workplace, as an organisational setting, offers a suitable environment for reorienting employees' daily routines toward the practice of environmental sustainability. This study addresses three central research questions: What discernible patterns exist in waste diversion and reduction practices over time within a workplace setting, both at the building-wide and tenant-specific levels? Does positive change in waste diversion practices within a workplace lead to a spillover effect, influencing employees' waste practices at home? How can shifts in waste diversion and reduction practices within a green office building be comprehensively conceptualized using the framework of social practice theory? Recognizing the importance of scale, this study employs a case study design to investigate the temporal evolution of waste diversion and reduction practices within a high-performance green building workplace context. By focusing on a specific case, the study examines how temporal shifts in these practices unfold, encompassing both tenant and building scales. Data collection methods encompass surveys to gather employee perspectives on waste diversion practices, waste assessments to analyse waste composition and generate quantitative insights, and daily monitoring of waste disposal activities to track and measure changes over time. Triangulating data from these sources ensures a comprehensive investigation. The findings reveal a positive trend in waste diversion practices at the building scale over time. At the tenant organizational scale, specific tenants exhibit significant improvements in both waste diversion and reduction practices, while others do not follow a similar positive trajectory. Moreover, this study underscores the workplace's role as a catalyst for sustainability beyond its boundaries. Positive changes in waste diversion practices at work can lead

to a spillover effect, influencing employees to adopt similar practices at home. However, this effect is not immediate, with changes in home waste diversion practices showing a delayed response compared to the workplace. This research has significant implications for scholars and practitioners, emphasizing the importance of considering different scales, conducting temporal analyses, applying social practice theory, and recognizing the workplace as a catalyst for sustainability. Interdisciplinary collaboration and long-term impact assessments are essential for advancing sustainability practices within workplace environments. In summary, this study offers a comprehensive analysis of waste diversion and reduction practices in a workplace setting, shedding light on positive trends and variations across organizational scales. It underscores the workplace's potential to drive sustainability beyond its confines and provides valuable insights for scholars and practitioners seeking to promote environmental sustainability.

## Acknowledgements

I would like to express my sincere gratitude to all those who contributed to the completion of this project. I am immensely appreciative of the support provided by my mentors, family members, friends, and colleagues. I am particularly thankful to Dr. Amelia Clarke and Dr. Paul Parker, my supervisors, for their invaluable guidance and the opportunities they presented me with during this journey. I extend my heartfelt thanks to them for their unwavering belief in me and their dedication to helping me produce the thesis.

I am grateful to all the research investigators at evolV1 and building citizens for their contributions.

To my family, I cannot express sufficient gratitude for serving as an enduring wellspring of inspiration and unwavering support, and for steadfastly believing in my educational aspirations. Your impact on my life is beyond measure. I wholeheartedly dedicate this extensive journey and the fruits of my effort to my father, Aba Gebrehiwot Moges, whose unwavering dedication has been a driving force behind my achievements.

Lastly, I want to express my deepest appreciation to my wife. Your unconditional support and encouragement have played a pivotal role in bringing me to where I am today. I am truly grateful for your presence in my life.

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## 1. Introduction

Sustainability, as a concept, encompasses a comprehensive approach that envisions and strives to achieve a desirable future characterised by the flourishing of human beings, long-term ecological integrity, social justice, and economic prosperity.

Numerous scholars including Ehrenfeld (2012), Elkington and Rowlands (1999), and Gladwin et al. (1995) emphasise the significance of sustainability as a holistic concept that recognises the interconnections among environmental, social, and economic dimensions. Sustainability management, as defined by Starik and Kanashiro (2013), involves formulating, implementing, and evaluating decisions and actions related to both environmental and socio-economic sustainability. This research primarily focuses on sustainability practices at the workplace building level, particularly within the context of high-performance green office buildings (HPGOBs) and tenant organisations.

Integrating sustainability into an organization's operation and management is widely acknowledged by researchers as crucial for ensuring long-term financial success and reducing social and environmental impact (Eang et al., 2023; Kiesnere & Baumgartner, 2019; Starik & Kanashiro, 2013). To achieve this, managers may need to foster a sustainability-oriented cultural attribute, which can translate into workplace environmental sustainability (WES) practices in all activities and routines performed within the organisation (Kiesnere & Baumgartner, 2019; Starik & Kanashiro, 2013). The

workplace, as an organisational setting, offers a suitable environment for designing cultural changes and reorienting employees' daily routines toward the practice of environmental sustainability (Klade et al., 2013). However, there is limited empirical evidence on how to effectively use culture as a driver for transforming unsustainable workplace practices within an organisational setting.

Existing literature primarily focuses on the factors that influence the integration of sustainability within an organisational culture. Many studies indicate that various levels and internal change agents within an organisation impact the implementation of sustainability practices within its structures (Kiesnere & Baumgartner, 2019; Murphy et al., 2022; Stoughton & Ludema, 2012; van der Heijden et al., 2012). Moreover, research explores how different departments and functional units of an organisation respond to organisational culture change toward sustainability (Pek & Bertels, 2015). External pressures from stakeholders and government regulations have also been studied as drivers for organisational culture change toward sustainability (Siebenhüner & Arnold, 2007).

However, the existing research on workplace environmental sustainability (WES) practices faces several key gaps. Firstly, studies often have a narrow scope, limiting our comprehensive understanding of WES practices. Second, there is a methodological gap in the literature, with limitations in multilevel analysis, and addressing the value-action

gap. Finally, the studies overlook the interplay between individual actions and broader social structures, neglecting the importance of considering the sociocultural context.

This research aims to provide empirical evidence on how long-lasting changes in specific sustainability practices can be achieved in a workplace. The study employs social practice theory to focus on a specific sustainability practice – waste diversion – and examines how these practices change over time related to social and cultural structures of a workplace. Furthermore, the research explores the importance of scale, considering both the tenant and building levels, in understanding how environmental sustainability practices evolve over time with a focus of waste diversion and reduction.

The main research questions addressed in this study are threefold.

1. What are the discernible patterns in waste diversion and reduction practices over time, both at the comprehensive building-wide level and the more granular tenant-specific level within a workplace? This is the central research question focuses on identifying and comprehending the discernible patterns that emerge within waste diversion and reduction practices. These patterns are examined not only at the broader and all-encompassing building-wide level but also at the more intricate and specific tenant-centric level within the distinct confines of a workplace environment.

This investigative endeavor is aimed at conducting a comprehensive and thorough examination of the evolving dynamics inherent to waste diversion and reduction practices in a workplace setting. The intention is to scrutinize the

gradual shifts that transpire over time, investigating how these practices evolve and transform. This exploration is underpinned by a dual-pronged approach that directs its attention to two distinct yet interconnected scales: firstly, the holistic and collective dimensions of the entire building, and secondly, the individualized and distinctive characteristics of each tenant that constitutes the building's collective workplace environment. Through this nuanced investigation, a deeper understanding is sought to illuminate the interplay between the overarching operational strategies of the building and the diverse behaviors and practices of the individual tenants within.

2. Does a positive change in waste diversion practices within a workplace lead to a spillover effect, influencing employees' homes? This research question aims to explore the spillover effect resulting from positive changes in workplace waste diversion practices. It investigates whether such changes have a ripple impact, reaching into employees' homes. This inquiry seeks to understand how alterations in waste diversion practices at work could potentially influence corresponding behaviours and routines within the domestic sphere. Through this examination, the research strives to illuminate the broader implications of workplace sustainability initiatives, potentially resonating positively in individuals' personal lives.
3. How can a shift in patterns of waste diversion and reduction practices in a green office building be comprehensively conceptualized using the framework of social practice theory? The framework draws on concepts from existing literature to

investigate explanations for waste diversion and reduction patterns within a workplace, encompassing both building and tenant levels. It aims to uncover factors shaping these patterns, emphasizing logical and reasonable influences using social practice theory. These factors could be tied to workplace contexts, including organizational policies, corporate culture, and interventions by current and other researchers involved in the broader research project. The scope of answers to this research question remains constrained within the literature review section, as it derives from the analysis of existing scholarly works and resources. The boundaries of available insights are set by the current state of knowledge and understanding presented in the literature.

Addressing these research questions holds significant importance for multiple reasons. Firstly, investigating discernible patterns in waste diversion and reduction practices within a workplace offers insights crucial for effective waste management strategies. Understanding these patterns aids in designing tailored interventions for both the collective building-wide context and the individual tenant-specific level. Secondly, exploring the potential spillover effect from positive workplace waste diversion changes to employees' homes contributes to a comprehensive understanding of the broader impact of sustainability initiatives. This insight informs policy-making and organizational efforts to promote sustainable behaviours beyond the workplace environment. Lastly, comprehensively conceptualizing shifts in waste diversion practices through the lens of social practice theory enhances the theoretical foundation of waste management studies. It enriches the discourse around workplace sustainability and provides a

roadmap for integrating theoretical frameworks into practical applications. In sum, these research questions collectively contribute to refining waste management practices, fostering environmental sustainability practices, and advancing the theoretical understanding of waste-related dynamics within workplaces.



## 2. Literature Review

“Sustainability” refers to a comprehensive approach that envisions and seeks to achieve a desirable future characterised by the flourishing of human beings, long-term ecological integrity, social justice, and economic prosperity. Scholars such as Ehrenfeld (2012), Elkington and Rowlands (1999), and Gladwin et al. (1995) have highlighted the importance of sustainability as a holistic concept that considers the interconnections among environmental, social, and economic aspects.

Sustainability management, as defined by Starik and Kanashiro (2013), involves the formulation, implementation, and evaluation of decisions and actions related to both environmental and socio-economic sustainability. In the context of this research, the focus is primarily on sustainability practices at the workplace building level, specifically within the context of the HPGOB (high-performance green office building) as well as within tenant organisations.

According to the Merriam-Webster Dictionary, a workplace is a physical space, such as an office, shop, or factory, where people engage in work-related activities. These spaces are created and designed by organisations, and they encompass a wide range of sustainable routines and practices. Examples include waste diversion and reduction initiatives, energy conservation efforts, and other environmentally friendly actions at both the individual employee level and the organisational and workplace levels.

The subsequent subsections of this thesis perform a literature review focused on workplace environmental sustainability. This review explores existing scholarly work and empirical studies related to sustainable practices implemented within workplaces. By examining the current state of knowledge and understanding in this field, the research aims to contribute to a deeper understanding of the challenges and opportunities associated with promoting sustainability in workplace settings.

In summary, sustainability encompasses a multidimensional vision for the future that emphasises the wellbeing of both humans and the environment. Sustainability management involves making decisions and taking actions that promote environmental and socio-economic sustainability. Within the workplace, there is significant potential for implementing sustainable practices, and this research will review the literature on workplace environmental sustainability to illuminate the existing body of knowledge in this area.

## 2.1. Workplace Environmental Sustainability

Workplace as an organizational setting could be used as a suitable place for creating changes on daily unsustainable routines of employees (Klade et al., 2013; Süßbauer & Schäfer, 2019). Over the past decade, a wide range of workplace environmental sustainability studies have been undertaken (Bissing-Olson et al., 2013; Blok et al., 2015; Boiral, 2009; Ciocirlan et al., 2020; Coleman, 2016; Hargreaves, 2011; Inoue & Alfaro-Barrantes, 2015; Kawabata, 2021; Kiesnere & Baumgartner, 2019; King, 2019; Klade et al., 2013; Mirvis & Manga, 2010; Mouchrek, 2018; Nash et al., 2017; Paillé &

Boiral, 2013; Paxton-Beesley, 2020; Reimer-Watts et al., 2022; Robertson & Barling, 2013; Siebenhüner & Arnold, 2007; Stoughton & Ludema, 2012; Süßbauer & Schäfer, 2019; Unsworth et al., 2013; van der Heijden et al., 2012; Wesselink et al., 2017; Wu et al., 2013, 2016; Yuriev et al., 2018).

Most of the research focuses on factors that influence individual employee pro-environmental behaviour, such as individual employee and manager personal characteristics (Bissing-Olson et al., 2013; Boiral, 2009; Ciocirlan et al., 2020; Wesselink et al., 2017); contextual factors range from simple workplace physical contexts (such as recycling signage) (Hargreaves, 2011; Wu et al., 2016, 2018) to changing an overall materiality of workplace setting (Coleman, 2016; Dreyer et al., 2018; Kawabata, 2021; King, 2019; Paxton-Beesley, 2020; Zitars et al., 2021). Parts of workplace environmental sustainability research also focus on how organisational contexts such as size of company, change agents in organisation, organisational values and norms (Helferty et al., 2009; Kiesnere & Baumgartner, 2019; Miska et al., 2018; Ordonez-Ponce & Clarke, 2020; Samuel & Clarke, 2022; Siebenhüner & Arnold, 2007; Süßbauer & Schäfer, 2019; van der Heijden et al., 2012), and a comprehensive change in workplace culture toward sustainability (Reimer-Watts et al., 2022). The literature review examines workplace environmental sustainability (WES) behaviour and practice through two categories: literature that approaches WES using social psychology and social practice approaches.

## 2.2. Workplace Environmental Sustainability (WES) studies using social psychology approach

WES studies using social psychology noted that a collective individual employee pro-environmental action can reduce workplace environmental impacts (Mckenzie-Mohr, 2000; Osbaldiston & Schott, 2012; Oskamp, 2000; Wesley, 2014). Within the context of WES, the field of social psychology provides insight on how individual employees are influenced by their own behavioural characteristics, social surroundings, cultural norms, and organisational contexts (Breadsell et al., 2019). Under the social psychology approach, we view individuals as the centre of analysis (Breadsell et al., 2019) for designing organisational changes.

Studies have reported a mixed effect of most employees' behavioural characteristics as determinants of WES behaviour (Young et al., 2015; Yuriev et al., 2018). For example, an employee's attitude toward environmental behaviour (Bissing-Olson et al., 2013) and toward their organisation – such as trusting their managers (Andersson et al., 2005) – can determine WES behaviour. Other research articles, such as by Blok et al. (2015), however, noted that attitude and proactive environmental behaviour per se can be difficult to locate. Some studies have shown that the attitude-behaviour relationship is strongest when contextual factors remain neutral; however, when contextual factors influence WES behaviour in either a positive or negative direction, the strength of the attitudes-behaviour influence are minimised (Nye & Hargreaves, 2010; Wesselink et al.,

2017). Evidence such as that from Nye and Hargreaves (2010) could mean that social psychological theories (e.g., theory of planned behaviour) are narrow with respect to explaining WES behaviour.

The importance of workplace contextual and situational factors is another aspect of the WES literature investigated under the category of social psychology. Research articles under this category outline some of the contextual factors designed through behavioural change intervention (Ciocirlan et al., 2020; Unsworth et al., 2013), e.g., encouraging employees (Blok et al., 2015) through training or changing the workplace infrastructure (Young et al., 2015). However, it remains difficult to trace the most effective interventions for influencing WES behaviour. A study conducted on alterations in the overall physical work environment – specifically the infrastructure of a workplace – did not prove fully effective in influencing the actual practice of work environment sustainability (WES; Wu et al., 2018). In Wu et al.'s (2013) study, it was discovered that although the ambiance of a building did stimulate environmental behaviour such as recycling, it did not lead to a change in the amount of contaminated waste. Likewise, Valkengoed et al. (2022) conducted a recent literature review on modifying environmental behaviour and emphasised the significance of targeting key factors that influence a specific environmental behaviour. They provided a procedure for selecting interventions to promote such behaviour. However, the implementation of these procedures in real-world scenarios is challenging because of fragmented and inconsistent contextual factors. Consequently, the wider applicability of studies using social psychological approaches is limited, making it difficult to generalise findings.

There is much to address at the organisational level, factors such as organisational values, structures, and change agents; management support, policy, and strategy; mission and vision of the organisation; financial and personnel resource availability; size of the company; and formal and informal organisational culture (Miska et al., 2018; Ordonez-Ponce et al., 2021; Ordonez-Ponce & Clarke, 2020; Siebenhüner & Arnold, 2007; Young et al., 2015). These are all important factors in influencing organisational performance, such as financial outcomes (Linnenluecke & Griffiths, 2010; Siehl & Martin, 1989). However, very little is known about exactly how these factors may influence a specific WES outcome (Young et al., 2015). In their literature review Young et al., (2015) argued that effective changes in WES behaviour could be achieved if the organisation could design a combination of interventions by providing physical facilities and employ tailored persuasive communication to engage employees in environmental sustainability practices.

One of the WES behaviour interventions is participatory, aimed at engaging employees through their will and participation. Researchers argue that participatory interventions could be an effective way to engage employees in WES behaviour (Endrejat & Kauffeld, 2018) and have further impact on creating a long-lasting culture oriented toward sustainability (Mouchrek, 2018). However, there is limited empirical research on how participatory interventions could impact the culture of sustainability. Mouchrek (2018) investigated participatory design approaches among youth in an educational setting; the study found that participatory approaches supported a culture of sustainability

development among the youth. In the present investigation, we posit that the sociocultural and organizational milieu within a workplace possesses the potential to exert an impact on the alteration of patterns pertaining to environmental sustainability practices, encompassing waste diversion and reduction practices as a specific instance. Within the broader research project, in which the current study is included, Reimer-Watts et al. (2022) conducted a study revealing that a participatory intervention involving researchers and building citizens (employees of the tenant organization) in a high-performance green office building facilitated the development of a sustainability-oriented culture (Reimer-Watts et al., 2022).

Regarding the methodological approaches used for WES behavioural research, two important methodological aspects could contribute to the generalisability of the research findings. One is the lack of multilevel analysis (institutional, organizational, overall workplace at building level, leader, team, and employee) across the literature (Lo et al., 2012; Norton et al., 2015). Authors suggest that the use of multilevel analysis is needed to uncover complex environmental behaviour (e.g., dynamic fluctuations and patterns of the target behaviour) and its effect at multiple scales in a workplace (Norton et al., 2015).

Second, most of the WES behavioural research is cross sectional and uses self-reporting tools for data collection. The limitations of such research methods are well known in the way that cross-sectional studies are limited in providing insight into how environmental behaviour changes over time. Cross-sectional studies lack the ability to

identify patterns of stability, change, or variability in variables across time, which hinders a deeper understanding of how factors interact and influence each other. (Norton et al., 2015; Podsakoff et al., 2012).

The validity of self-reported environmental behaviour measurements is also limited by the “value-action gap,” a gap between employees’ reported environmental values and their actual behavioural actions. A meta-analysis review noted a weak correlation between self-reported behaviour and actual behaviour (Kormos & Gifford, 2014). The significance of conducting multilevel analysis in examining environmental behaviour within a workplace is emphasised by the authors (Lo et al., 2012). They further suggest using a research design, such as a longitudinal experimental study, along with suitable measurement tools such as waste analysis and energy measurements, to investigate the changes in workplace environmental sustainability practices over time (Norton et al., 2015).

In the realm of workplace environmental sustainability (WES) literature that incorporates social psychology, three significant gaps can be identified. First, many studies focusing on WES and employing social psychology tend to have a narrow scope, providing only partial insights into the changes in WES practices over time. Consequently, a comprehensive understanding of WES practices remains elusive. This knowledge gap limits our ability to fully comprehend and explain WES practices.



Finally, authors grounded in social practice theory have criticised social-psychological approaches for centring their analyses on the individual, neglecting the crucial link between structure and agency. Scholars such as Reckwitz (2002), Shove et al. (2012), and Süßbauer and Schäfer (2019) have underscored the need to consider broader social structures and practices in understanding practice. By overlooking this perspective, social psychological approaches may fail to capture the complex interplay between individual actions and the broader sociocultural context, which is essential for a comprehensive understanding of WES practices.

To bridge these gaps, the current research proposes the use of social practice theory to gain deeper insights into how the social, organizational, and material structure of a workplace could influence WES practices over time. Social practice theory offers a conceptual framework that enables a holistic examination of the intricate dynamics among individuals, their behaviours, and the wider social and physical environments in which they operate. Adopting this theoretical lens allows for multiple levels of analysis within a workplace, encompassing both organisational and building levels.

By embracing social practice theory, researchers can move beyond the limitations of narrow studies, incorporate multilevel analyses, address patterns of change in WES practice, and consider the interplay between structure and agency. This comprehensive approach facilitates a more nuanced understanding of how WES practices evolve and transform over time, illuminating the intricate mechanisms underlying sustainable practice within workplaces.

In conclusion, integrating social practice theory into the study of WES practices can help overcome the three main gaps identified in the existing literature. By doing so, researchers can develop a more comprehensive understanding of WES practices, explore patterns of change, incorporate multilevel analyses, and consider the interplay between individual actions and broader social structures. This approach holds significant potential for advancing knowledge in the field of workplace environmental sustainability.

### 2.3. Workplace Sustainability: A Social Practice Theory (SPT) Approach

Understanding workplace environmental sustainability (WES) practices through the lens of social practice theory (SPT) begins with the recognition that reducing resource consumption involves targeting the activities, routines, and practices in the workplace that involve resource use. Scholars of SPT argue that practices should be the focus when designing changes in resource consumption. Reckwitz (2002) p. 249 defines practice as “a routinized type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, things and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge.” These interconnected elements of practice lead to behavioural action. Moreover, practices are social in nature because they are shared and manifest at different levels of society, space, and time (Reckwitz, 2002). Workplace practices are linked to the social, cultural, and organisational

conditions within the workplace setting, representing the practical carrying out of social life (Halkier et al., 2011).

Practices typically involve a bundle of coordinated performances of other practices. For instance, the practice of driving involves actions such as fastening seat belts, controlling speed, steering, and interpreting traffic situations (Kurz et al., 2015; Shove et al., 2012). According to Shove et al. (2012), the formation and maintenance of a practice require a combination of three distinct elements: materials, skills, and meanings (see Figure 1a). Materials refer to the physical artefacts, infrastructure, and technology involved in performing the practice. Skills encompass the procedural knowledge and expertise necessary for engaging in the practice. Meanings involve the shared understanding, assumptions, values, and symbols associated with the outcomes or goals of the practice (Shove, 2003; Southerton & Yates, 2014). These elements of practice exist beyond the specific practices themselves (Nash et al., 2017). For example, the materiality of infrastructure or buildings serves as an element that influences the dynamics of multiple practices simultaneously.

By adopting the SPT perspective, researchers gain a deeper understanding of WES practices by examining the interconnectedness of various elements within the practices. Rather than focusing solely on individual behaviours, this approach considers the material, skill-based, and meaning-based aspects that shape sustainability practices in the workplace. Understanding the material component involves recognising how physical infrastructure, technology, and artefacts facilitate or hinder sustainable

behaviours. The skill-based element examines the knowledge, competencies, and capabilities required for engaging in sustainable practices. The meaning-based aspect explores the shared understanding, values, and cultural norms associated with sustainability outcomes. By analysing these elements and their interplay, researchers can identify leverage points for promoting sustainable behaviours and designing effective interventions (Shove et al., 2012).

Adopting a social practice theory (SPT) approach provides valuable insights into understanding and promoting workplace environmental sustainability practices. By recognising the interconnected elements of practices – including materials, skills, and meanings – researchers and practitioners can develop targeted interventions that address the complexity of sustainability practice in the workplace. This approach offers a comprehensive understanding of the social, cultural, and organisational factors that influence sustainable practices, leading to more effective strategies for creating sustainable workplaces.

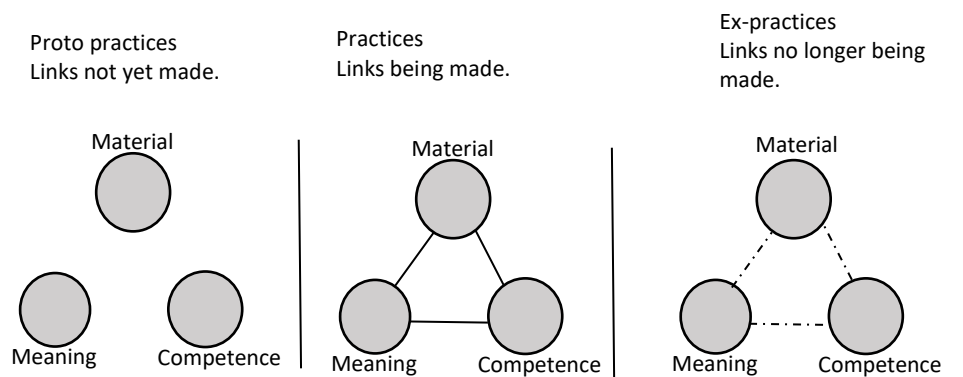
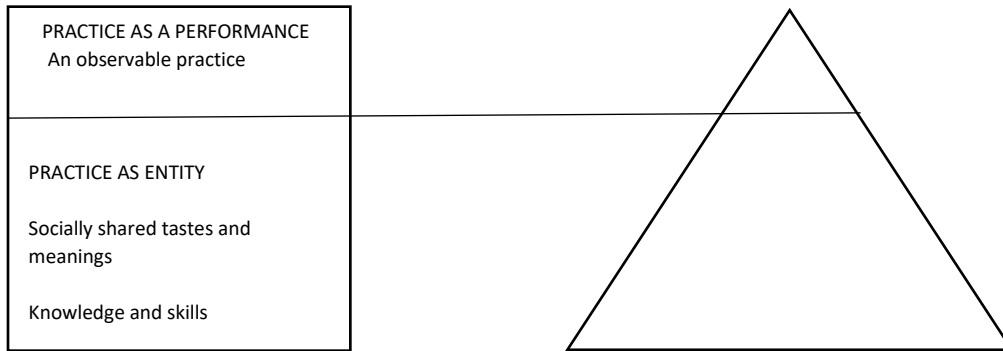


Figure 1 Nature of Practice adapted from Shove et al. (2012)

An essential aspect of understanding practice lies in recognising the dynamic relationship between its elements. Over time, new practices emerge while existing practices become obsolete, driven by changes in the three core elements of material, skill, and meaning (Shove et al., 2015). This dynamic nature of practice can be observed in various examples, such as Nordic walking (Shove & Pantzar, 2005), showering (Hand et al., 2005), and refrigeration practices (Hand & Shove, 2007). For instance, a study conducted in the UK revealed a shift from the practice of weekly hygienic bathing to daily showering because of the availability of suitable infrastructure, resulting in a transformation of the meaning associated with showering from pure hygiene to a refreshing experience (Hand et al., 2005).

Effecting change in practice necessitates an understanding of the two states of practice: practice as performance and practice as an entity. Practice as an entity refers to practices that exist as spatio-temporal entities with the configuration of the three elements embedded within cultural structures (Halkier et al., 2011). It recognises practices as complex social phenomena shaped by the cultural, social, and historical contexts in which they occur. On the other hand, practice as a performance refers to the observable behaviours or actions exhibited by individuals or society in different contexts, resulting from the combination of the three elements (Shove et al., 2012; Spurling et al., 2013).



*Figure 2 Practice as a performance and entity; observable practice/behaviour is the tip of the iceberg adopted from Spurling et al. (2013).*

From the perspective of practice as performance, it becomes evident that practices exhibit repetitive patterns and can undergo changes when practitioners collectively display a decreasing enthusiasm for habitual behaviours. Changing a practice as an entity can be approached through three suggested routes proposed by Shove et al. (2012) and Spurling et al. (2013): re-crafting practices, substituting practices, and changing how practices interlock.

Re-crafting practices involves modifying the elements of the practice to facilitate change. This could entail introducing new materials, acquiring new skills or competencies, or shifting the meanings associated with the practice. By altering the configuration of the elements, practitioners can transform their practice and promote more sustainable behaviours.

Substituting practices involves replacing less sustainable practices with more sustainable alternatives. This approach acknowledges that some practices may

inherently lack sustainability and must be replaced entirely. For example, substituting conventional fossil fuel-based transportation with electric vehicles or cycling can contribute to a more sustainable transport practice.

Changing how practices interlock refers to understanding the intricate interactions and dependencies between different practices and leveraging these connections to promote sustainable behaviours. Practices are interconnected and often reinforce one another. By identifying these interconnections and their influence, practitioners can initiate changes in multiple practices simultaneously, leading to systemic and lasting transformations.

Our research aimed to support, with empirical evidence, two important aspects of social practice theory. First, practices are nested and dispersed across space and time (Schatzki, 2020). Second, practices are embedded in socio-cultural and organizational structures (Halkier et al., 2011). To investigate these aspects, the following subsections provide a comprehensive review that focuses on these two fundamental components of practices. Through a careful examination of empirical data and relevant theoretical perspectives, we aim to contribute to a better understanding of social practice theory and its application in our specific research area. By providing supporting evidence for the nested and dispersed nature of practices as well as their cultural embeddedness, we hope to advance knowledge in this field and facilitate further exploration of practices in various contexts.

### 2.3.1. Practice across space and time (Scale)

Scale, in the context of research investigation, refers to the dimensions used to measure objects and processes, including spatial, temporal, quantitative, or analytical dimensions (Gibson et al., 2000). Although scale has been extensively used in the natural sciences, its explicit use and precision in the social sciences have been relatively less common and more variable (Gibson et al., 2000).

Recognising the importance of scale is crucial for researchers aiming to accurately analyse changes in a phenomenon. Bowen et al. (2018) emphasise that addressing scale-related issues is a vital first step in generating accurate and reliable analyses. They identify four fundamental ways in which scale is significant in the social sciences: identifying patterns and problems, explaining observed patterns, generalising propositions across different scales, and optimising processes or functions (Bowen et al., 2018).

When studying changes in practice, considering the appropriate scale is essential. Doing so allows researchers to uncover a new set of properties that may arise from new arrangements across different scales within the study context (Jones, 2014). By incorporating scales into the framework of SPT, there is an opportunity to explore the potential variations in practice over time when measured across different scales within the study setting (Bowen et al., 2018).



Applying scale-related considerations in research enables the identification of patterns and trends that may emerge at different levels, such as individual, organisational, community, or societal. It provides a nuanced understanding of how practices are influenced by and interconnected within various scales of analysis.

Furthermore, studying practice across scales facilitates the explanation of observed patterns and phenomena. By analysing practices at multiple scales, researchers can explore the complex interactions and dynamics that shape social practice and identify the underlying mechanisms and processes that drive changes in practice.

In addition, considering scale allows for the generalisation of findings from one level of analysis to another within the same scale. This enables researchers to draw broader conclusions and make propositions that apply to different contexts and settings within the same scale.

Lastly, scale-related considerations contribute to the optimization of processes and functions. By examining practices at different scales, researchers can identify opportunities for intervention and improvement, whether at the individual, organisational, or societal level. Understanding the dynamics and interdependencies

across scales provides insights into how interventions can be tailored to effectively achieve desired outcomes.

Incorporating scale into the study of social practice theory offers a valuable framework for understanding the complexity of practice and its dynamic nature. By recognising and addressing scale-related issues, researchers can unlock new insights and reveal the multifaceted aspects of practice that unfold across different dimensions. This comprehensive approach enhances our understanding of how practices change over time and allows for more informed decision-making, policy development, and intervention strategies aimed at promoting sustainable social practices.

Social practice theory offers a valuable framework for examining how practices are dispersed and exist across different scales. However, there is a lack of empirical evidence supporting the significance of scale in understanding changes in sustainable practices. Breadsell et al. (2019) present a theoretical exploration of resource consumption across scales, specifically focusing on the home, community, and society. Their research investigates the relationships and interdependencies between practices at these different scales. The authors argue that social practice theory can contribute to addressing scale-related issues, particularly in terms of space and time, when making decisions related to daily resource consumption. By considering the various scales at which practices operate, researchers can identify opportunities for change that intersect across different spatial and temporal dimensions. For instance, when organisations

transition to green office buildings, such a change in the workplace setting presents an opportunity to foster environmental sustainability practices.

Incorporating scale-related considerations into social practice theory allows us to explore the dispersion of practices across different scales. Although empirical evidence in this area is limited, theoretical explorations have highlighted the potential of understanding practices in relation to space and time. Recognising the importance of scale when designing interventions. The next section of this research reviews cultural change and its implications for environmental sustainability.

### 2.3.2. Workplace Culture

Social practice theory provides a framework for understanding the social and cultural structures that surround a particular practice. According to Halkier et al. (2011), studying how practices change over time can offer insights into the dynamics of culture and social change. In addition, cultural and social structures can act as sources of resistance when attempting to introduce changes to a practice through intervention.

In the context of workplace environmental sustainability (WES) practices, culture – particularly organisational culture and structure – plays a significant role. Banks et al. (2012) and King (2019) emphasise the impact of culture on WES practices. Therefore, it is argued that a comprehensive cultural change intervention can effectively influence a given WES practice. King's (2019) research findings underscore the importance of

exploring organisational culture and practices before designing workplace environmental sustainability interventions.

Defining culture poses a challenge because there is no single dominant definition. Nevertheless, researchers commonly approach culture from a similar perspective and make certain assumptions (Howard-Grenville & Bertels, 2012). In this research, we adopt Packalén's (2010) definition, which encompasses two broad elements. First, culture includes traditional elements associated with cultural policy, such as theatre, film, music, art, architecture, literature, and museums. Second, culture is viewed as an anthropological and sociological concept, encompassing norms, values, assumptions, traditions, and practices.

The focus of this study lies primarily on the anthropological and sociological concept of culture, which comprises norms, values, assumptions, routines, and practices.

Organisational culture is often understood as a pattern of shared assumptions with three major aspects: values (including strategies and goals), artefacts (visible structures and processes, both textual and visual), and underlying assumptions (beliefs and perceptions) (Reidenbach & Robin, 1991; Schein, 1991). Notably, organisational culture binds individuals and organisations together (Mintzberg, 2009).

Shared values and norms within an organisation shape what is deemed appropriate and desirable in terms of workplace actions (Howard-Grenville & Bertels, 2012).

Consequently, new members automatically adopt the existing organisational culture as the correct way to perceive, think, feel, and perform work (Schein, 1991).

The literature identifies two main aspects of organisational culture. One aspect pertains to the deeper underlying domain rooted in collective values, assumptions, and beliefs; the other involves the symbolic manifestation of these underlying domains (Forbes & Jermier, 2012). Regarding integrating sustainability into organisational culture, some organisations have successfully incorporated sustainability into the underlying domains of culture while others have overlooked it (Baumgartner, 2009; Forbes & Jermier, 2012). Furthermore, some organisations face challenges in translating sustainability into practice while others find it less daunting (Starik & Kanashiro, 2013).

The presence of multiple cultures and subcultures within an organisation is also highlighted in the literature (Linnenluecke & Griffiths, 2010). Subcultures may emerge and manifest around occupational groupings, functional areas, and hierarchical structures within an organisation (Howard-Grenville & Bertels, 2012). Personal interactions, networks, and individual demographic characteristics – such as ethnicity and gender – all contribute to the formation of these multicultures and subcultures (Linnenluecke & Griffiths, 2010). Scholars emphasise the importance of investigating how unified cultural norms, multicultures, and subcultures can impact desired changes in organisational culture toward sustainability (Howard-Grenville & Bertels, 2012; Linnenluecke et al., 2009).

To illustrate the dynamics of organisational culture and sustainability, a real-world example from the literature could be the case of a manufacturing company that aims to implement sustainable practices throughout its operations. The organisation might face challenges in aligning the underlying assumptions and values of its diverse subcultures with its sustainability goals. For instance, the production department may prioritise cost efficiency over sustainability while the marketing department may focus on green branding. Bridging these divergent cultural perspectives and fostering a unified cultural norm that emphasises sustainability would be crucial to driving organisational change.

In summary, social practice theory provides insights into the social and cultural structures that surround practices, and studying how practices change over time illuminates culture and social change dynamics. Organisational culture – composed of shared values, artefacts, and underlying assumptions – significantly influences WES practices. Integrating sustainability into organisational culture can be challenging but is necessary for driving change. Multiple cultures and subcultures within organisations further complicate the process, emphasising the importance of investigating unified cultural norms and their impact on desired changes toward sustainability.

### 2.3.3. Waste diversion and reduction as an example of environmental sustainability practice

This study focuses on waste diversion as a social practice within the context of workplace environmental sustainability. Waste diversion involves actions such as recycling and composting, which aim to divert waste from landfills and instead channel it

into appropriate material streams. However, in practice, only a small portion of recyclable or compostable materials enter the recycling or composting systems (Evans, 2011).

The integration of waste diversion and reduction practices into mainstream behavior patterns brings about far-reaching implications for waste management strategies, resonating with broader aspirations for sustainable development. Waste diversion and reduction practices serve as efficient mechanisms for conserving valuable resources. By extending the lifespan of materials through recycling and reuse, these practices contribute to the diminished demand for raw materials, energy, and water, aligning with the principles underpinning the circular economy paradigm (Stahel, 2016).

The adoption of waste diversion practices precipitates a tangible shift in the composition of the waste stream. The reduction in the volume of residual waste destined for landfills or incineration necessitates adaptations within waste management facilities, prompting the exploration of innovative technologies for processing diverse waste streams.

As waste diversion and reduction practices curtail the quantum of waste generated and avert its consignment to landfills, they manifestly reduce the emission of greenhouse gases and the contamination of soil and water resulting from waste decomposition. This alignment with climate change mitigation and environmental conservation underscores the role of waste management in holistic sustainability.

Successful integration of waste diversion and reduction strategies cultivates heightened public engagement and awareness concerning waste-related concerns. Empowered by

these practices, individuals are more likely to embrace their roles as stakeholders in waste management, fostering a profound sense of environmental responsibility.

The realization of effective waste diversion and reduction practices hinges upon supportive policy frameworks and governance structures. Governments and local authorities emerge as indispensable agents in establishing an enabling environment through the formulation of incentives, regulations, and strategic infrastructure development.

Waste diversion and reduction are deeply intertwined with the individual, social, and cultural structures of a workplace. By examining the social practice of waste diversion, we can explore various aspects such as social assumptions, materiality, and competency related to waste management. This perspective allows us to understand how waste diversion is influenced and shaped by the social and organisational structures within a workplace.

Viewing waste diversion as a social practice provides a valuable framework for understanding the underlying dynamics at play. It recognises that waste management is not solely a technical or operational issue but rather a multifaceted process influenced by social norms, values, and behaviours. By studying waste diversion from this perspective, we can gain insights into how social and cultural structures impact the success or failure of waste management efforts in a workplace.



#### 2.3.4. Conceptualising workplace environmental sustainability using the lens of social practice theory

The limited research articles that have attempted to conceptualise workplace environmental sustainability (WES) practices using social practice theory (SPT) have provided valuable insights into understanding the dynamics of sustainable practices in green office buildings. Two key studies – King et al. (2013) and Süßbauer and Schäfer (2019) – have contributed to the development of conceptual frameworks that illuminate the contextual factors (green building) and life stages influencing WES practices, respectively.

King et al. (2013) focused on the post-occupancy evaluation of green office buildings and proposed a conceptual framework within the context of building management sustainability initiatives and office building policies/regulations. Their framework identified these contextual factors as significant influences on the adoption and implementation of environmental sustainability practices. By considering the larger organisational and regulatory context, the authors highlighted the importance of supportive policies and initiatives in driving sustainable practices in green buildings. This framework provides a foundation for understanding how external factors can shape WES practices within a workplace setting.

Süßbauer and Schäfer (2019) took a more detailed approach by operationalizing SPT in exploring the emergence and transformation of sustainable practices within workplaces.

They proposed three life stages for changing unsustainable routines: opportunities, experimentation, and stabilisation. In the opportunities stage, the authors emphasised the significance of organisational sustainability goals and the introduction of new materials, technologies, and organisational structures. Although creating opportunities is important, the authors highlighted that actual practices must be performed for changes to occur. The experimentation stage involved allowing employees to interact with the sustainable structure of the workplace, giving them the chance to engage with and explore sustainable practices. This stage was seen as crucial to stimulating changes in social practices. Finally, the stabilisation stage focused on the ongoing repetitive performance of sustainable practices over an extended period. By highlighting these life stages, Süßbauer and Schäfer provided a dynamic perspective on the process of transitioning from unsustainable to sustainable practices within a workplace.

These two research articles directly contribute to the conceptualisation of the current study by providing insights into the contextual factors and life stages influencing WES practices. The framework proposed by King et al. (2013) acknowledges the importance of building management sustainability initiatives and office building policies/regulations as influential factors. Meanwhile, the framework developed by Süßbauer and Schäfer (2019) offers a more detailed understanding of the life stages involved in changing unsustainable routines in a workplace, emphasising the need for opportunities, experimentation, and stabilisation.

By integrating the findings and concepts from these two studies, the current research can build upon existing knowledge and contribute to a deeper understanding of WES practices within a specific organisational context. The research can further explore how the contextual factors identified by King et al. (2013) interact with the life stages proposed by Süßbauer and Schäfer (2019) to shape the adoption and implementation of sustainable practices. This integration of frameworks will provide a comprehensive perspective on the dynamics of WES practices and offer valuable insights for organisations aiming to promote environmental sustainability in their workplaces.

The purpose of this section is to conceptualize the potential evolution of waste diversion and reduction practices within a workplace setting, specifically in the context of high-performance green office building (HPGOB). This conceptualization is guided by the application of social practice theory (SPT). The framework synthesized through this research delves into the dynamics of practice evolution across both tenant and building levels, considering the influential social and cultural dimensions within the workplace setting.

Figure 3 and Table 1 are conceptual framework illustrate how practice of waste diversion in a workplace could evolve over time and how various elements of a specific environmental sustainability practice (waste diversion and reduction) could be influenced by the social, cultural, and organizational structures of a workplace. The framework provides insights into how observable practices, such as waste diversion, can vary within a workplace, considering tenant and building scale of the workplace.

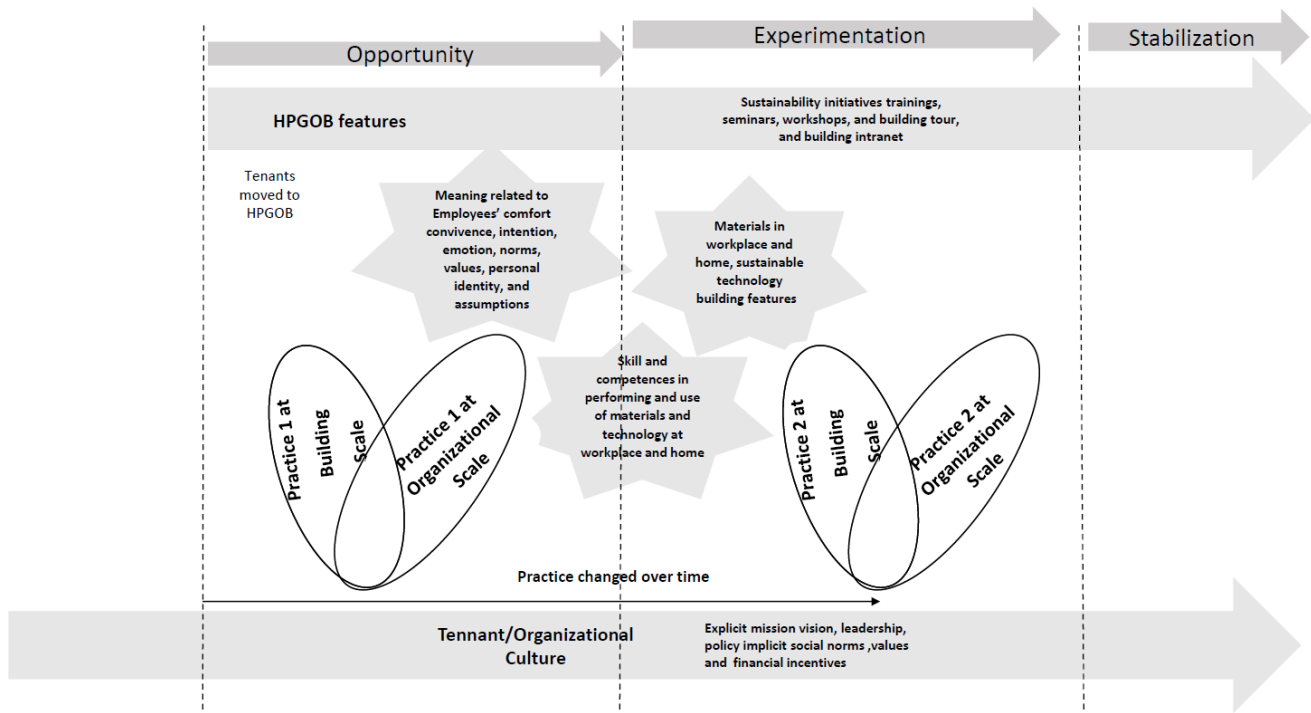


Figure 3 The conceptual framework illustrates the temporal evolution of workplace environmental sustainability practices and their variations across different workplace scales. It captures the intricate interplay of social, cultural, and organizational factors within this context. Adapted from King et al. (2013) and Süßbauer and Schäfer (2018).

Table 1 Social practice of a WES influenced by scale at tenant and building levels

Social practice of waste diversion (elements) (Shove et al., 2012)	Tenant/Organizational Scale	HPGOB
Meaning	Explicit mission vision and policy; implicit social norms and values, etc. Süßbauer & Schäfer, 2019).	Norms, shared feelings, office management (building regulations, policy, rules, etc.), and sustainability initiatives, comfort, wellbeing, etc. (King et al., 2014; Süßbauer & Schäfer, 2019)
Material	Materials and technology limited to the specific corporation, for example, waste bin signage, financial incentives, etc. (Süßbauer & Schäfer, 2019)	Green features of the building (such as solar panel, green wall, stairs, etc.) (King et al., 2014)
Competence	Formal training, informal and inspiring learning environment, organization intranet, etc. (King et al., 2014; Süßbauer & Schäfer, 2019)	Co-creation of culture of sustainability, formal and informal training, seminars, workshops, and building tour to all new occupants, building intranet, etc. (King et al., 2014)

The study highlights that the process of changing WES practices begins when tenants move to an HPGOB. This relocation is seen as an opportunity for initiating and influencing changes in WES practices. Three important contexts should be considered in this process.

First, the study emphasises any sustainability initiatives across HPGOBs. This refers to the collective efforts of tenants and other stakeholders in developing shared norms, values, and beliefs regarding sustainability. The study recognises the significance of fostering a collaborative culture that supports sustainable practices.

Second, the existing organisational culture held by tenants before and after moving to an HPGOB is considered. The study acknowledges that tenants bring their pre-existing shared norms and values to the new workplace environment. Understanding and leveraging these organisational cultures can play a crucial role in facilitating the adoption and integration of sustainable practices.

Lastly, the HPGOB context itself is recognised as a physical and material intervention that could shape environmental sustainability practices. The design, infrastructure, and amenities provided within an HPGOB can act as enablers or barriers to sustainable practices. The physical attributes of the building, such as waste management systems and energy-efficient technologies, can influence the adoption and sustainability of WES practices.

Overall, these three contexts – the co-creation of a culture of sustainability across HPGOBs, the pre-existing organisational culture of tenants, and the HPGOB context itself – collectively influence the evolution of WES practices over time, both at the individual tenant level and the broader building level. The study's framework provides a comprehensive perspective on the multidimensional factors that could influence WES practices.

By understanding these contexts and their interconnectedness, organisations and stakeholders can gain insights into the dynamics of WES practices and implement

strategies to foster sustainable practices and norms within HPGOBs. The study's conceptual framework is a valuable tool for guiding future research and practice in promoting sustainability in the workplace.

#### Summary of the literature review

The literature review suggests that embracing a social practice theory allows us to understand how unsustainable practices can be transformed in a workplace setting.

This theoretical lens offers the opportunity to examine how a holistic cultural shift within a workplace can influence the social practice of workplace environmental sustainability (WES). The use of social practice theory allows for multiple analyses at both the organisational and building scales of a workplace. The research asserts that employing social practice theory can provide valuable insights into conceptualising how organisational and social structures could contribute to long-term changes in WES practice.

In essence, using social practice theory provides a framework to understand the underlying dynamics of behaviour and societal norms that shape sustainability practices within a workplace. It acknowledges that sustainable practices are not solely individual actions but are deeply embedded in the collective social and organisational structures.

This perspective allows for a comprehensive examination of the interplay among individuals, social interactions, and the physical environment within the workplace.

In summary, employing social practice theory enables a deeper understanding of the potential for change in unsustainable practices within a workplace. It allows for a

comprehensive analysis of the organisational and social factors that shape the social practice of WES. Through the application of this theoretical perspective, we can acquire valuable knowledge on implementing cultural and structural changes that can foster environmental sustainability. This, in turn, contributes to the long-lasting transformation of workplace environmental sustainability.



### 3. Methods

#### 3.1. Research Design

Using a case study design, the present research investigates the temporal evolution of waste diversion and reduction practices within a green office building. Case studies are recognised as a valuable design of inquiry, particularly in the field of evaluation, where researchers delve into an in-depth analysis of a case, which could be a programme, event, activity, or process (Creswell & Creswell, 2017).

Case studies provide a way to thoroughly investigate real-life phenomena within their environmental contexts, whether they involve individuals, groups, or organisations. The researcher employs various data collection tools and often triangulates data to conduct a detailed exploration of the case (Creswell & Creswell, 2017; Ridder, 2017).

Case studies are particularly well suited for cultural and social evaluation work, with a long-standing history in business and management literature. This approach offers the potential to identify patterns within cases that can provide valuable insights into the phenomenon under study. Moreover, case studies can contribute to the development or elaboration of theories, making them a flexible and powerful research design (Ridder, 2017).

In the current study, a single case study design was used to gain a deeper understanding of how and why a practice changes over time within a high-performance green building workplace context. By focusing on a specific case, the current study examines how a temporal shift of waste diversion and reduction practices unfold in a workplace context, encompassing both tenant and building scales.

To capture a comprehensive picture of the case, three main data collection procedures were employed. First, surveys were administered to gather information from employees regarding their practice of waste diversion. These quantitative data provided insights into the employees' perspectives on workplace practices within the workplace and at home.

Second, waste assessments were conducted to evaluate the existing waste diversion and reduction practices. These assessments involved analysing the waste generated and, its composition. The waste assessment data served as a valuable source of quantitative information, complementing the survey data.

Lastly, daily monitoring and recording of waste disposal activities were performed to track and measure the weight of waste disposed. This data collection procedure allowed the monitoring of changes in waste generation and disposal patterns over time. The daily recordings provided another layer of quantitative data that helped validate and triangulate the findings from the survey and waste assessment data.

By using multiple data collection procedures, the researchers ensured a comprehensive and robust investigation of the case. The triangulation of data from surveys, waste assessments, and waste disposal recordings enhanced the validity and reliability of the findings, providing a more complete understanding any temporal shifts of waste diversion and reduction practices of a workplace.

### 3.2. Case Study Building

The case study site chosen for this research was a net-positive energy commercial multi-tenant office building – the first of its kind in Canada – which opened its doors in fall 2018. Spanning 104,000 square feet, this structure presented a unique opportunity to serve as a living laboratory for studying sustainability and energy efficiency. Through convenience sampling, the study selected the three largest tenants – Tenant A, Tenant B, and Tenant C –to participate in the research.

Tenant A, a clean tech innovation hub, consisted of four partners: a local non-profit organization focused on sustainability, an incubator for technological innovation, and two local university-based sustainability research centres. Tenant B represented a local office of an international accounting firm, while Tenant C was a local mobile tech company. These diverse tenants offered a comprehensive range of perspectives on sustainability within the building.

The design of the high-performance green office building (HPGOB) prioritised achieving a net-positive carbon footprint, as reported by the CGBC (2019). This goal was accomplished through the incorporation of various physical sustainability features.

Noteworthy among these features were a state-of-the-art HVAC system; a passive solar wall; a 40-foot, three-story living wall; a geothermal system; a 40,000-litre cistern; 28 electric vehicle charging stations; 754 solar panels on the roof; and an additional 1,440 solar panels covering the parking lot parkade. These cutting-edge technologies were specifically designed to generate 108 percent of the building’s estimated energy

consumption on-site, resulting in a reduction of 110 metric tonnes of CO<sub>2</sub> emissions per year – equivalent to the emissions from 130 cars (Reimer et al., 2021). Moreover, these sustainability-focused building features aim to encourage occupants to adopt sustainable behaviours while enhancing their overall wellbeing.

One prominent social aspect of the HPGOB regarding sustainability was the ongoing collaborative effort among building occupants to co-create a culture of sustainability (COS), as highlighted by Riemer et al. (2021). The COS initiative fostered a sense of community and collective responsibility toward sustainability within the building. By engaging tenants in the decision-making processes related to sustainability initiatives, the building management aimed to empower and motivate occupants to actively contribute to the building's environmental objectives. Refer to Appendix B and C for detailed information regarding the development of COS interventions conducted by other researchers within the overarching research project, of which the present study is a component.

In conclusion, the selected case study site – the net-positive energy commercial multi-tenant office building – offered a prime opportunity to investigate sustainability practises within a real-life setting. With its state-of-the-art sustainability features and a diverse range of tenants, the HPGOB showcased the potential for innovative design and technology to drive significant reductions in carbon emissions. Furthermore, the ongoing co-creation of a culture of sustainability among the building occupants demonstrated the

importance of social factors in promoting sustainable behaviours. This case study served as a valuable platform for understanding how practices of waste diversion and reduction shifts given the existing social and cultural aspects of the case study building.

### 3.3. Data Collection and Analysis

To investigate the changes in sustainability practises within the high-performance green office building (HPGOB), the research employed three types of data collection methods. These methods were carefully chosen to capture and quantify the observed changes and facilitate comparisons across different groups at both the building and tenant organisation levels.

The first data collection method used surveys, conducted at two different time points, and referred to as survey waves 0 and 1. Surveys were designed to gather information directly from the occupants of the building, allowing researchers to assess environmental sustainability practices both at work and at home. By administering surveys at different stages, researchers could measure and analyse the changes in these variables over time, providing valuable insights into the evolving sustainability practices within the HPGOB.

The second method employed was waste assessment, which involved conducting two separate assessments referred to as waste assessment 1 and waste assessment 2.

These assessments aimed to quantify the amount and composition of waste generated within the building. By comparing the results of the two assessments, researchers could identify any changes in waste management practices and evaluate the effectiveness of sustainability initiatives implemented to reduce waste generation and promote recycling or composting.

In addition, daily waste disposal recordings were monitored in the common kitchen area of Tenant A, one of the tenant organisations within the building. This method involved recording and analysing the types and quantities of waste disposed of in the kitchen area daily. This detailed monitoring allowed researchers to closely track and measure the immediate impact of sustainability initiatives on waste disposal practices within Tenant A, providing real-time data on their effectiveness.

By employing these three data collection methods, the research design aimed to provide a comprehensive understanding of the changes in sustainability practices within the HPGOB.

### 3.3.1. Survey

The study involved a substantial number of participants, with 148 individuals participating in survey wave 0 and 163 individuals participating in survey wave 1. Of these, 84 participants took part in both surveys, ensuring longitudinal data for analysis. The participants were distributed across the three tenants as follows: Tenant A had 76 participants, Tenant B had 174 participants, and Tenant C had 61 participants. Among

these, 11 participants from Tenant A, 64 participants from Tenant B, and 9 participants from Tenant C responded to both surveys.

The large sample size in this case study contributes to the validity and reliability of the research. A larger sample size provides greater confidence in the findings and allows more robust statistical analysis, making the results more representative of the population and increasing the generalisability of the study.

The survey questionnaire, consisting of seven items, was designed to measure the practice of waste diversion both in the workplace and at home. The questionnaire received approval from the Wilfrid Laurier University Research Ethics Board and the University of Waterloo Research Ethics Committee before being distributed to the study participants in November 2018 (survey wave 0) and November 2019 (survey wave 1). For this research, three survey questions related to waste diversion were considered.

The collected survey data were entered and processed using Statistical Analysis System (SAS) software; for convenience, the data were later exported to the Statistical Package for the Social Sciences (SPSS) for further analysis. To compare the practices of waste diversion, the three study variables – paper/cardboard diversion; plastic, glass, and container diversion; and compost diversion – were averaged based on each participant's responses, resulting in an additional main study variable called "waste diversion."

Descriptive statistics were calculated for each variable across each survey wave, considering the type of tenant organisation and the building level. To explore whether there were changes in the practice of waste diversion, parametric test assumptions were initially performed using SPSS. However, none of the study variables exhibited normality or homogeneity of variance under the parametric test assumptions.

As a result, a nonparametric Mann-Whitney U test (McKnight & Najab, 2010) was employed to investigate the change in self-reported practices of waste diversion between survey waves 0 and 1 for each tenant organisation and the entire building. A Kruskal-Wallis's test (McKnight & Najab, 2010) was also conducted to determine if there were differences in reported waste diversion practices among the tenant organisations. Subsequently, a series of Mann-Whitney U post-hoc tests was performed to further explore the specific differences between groups. A similar test procedure was used to assess changes in waste diversion practises at home.

After the applicable statistical assumptions were tested, Spearman's correlation was used to examine whether there was a relationship between waste diversion practices at the workplace and at home. This analysis aimed to uncover any potential associations between the two contexts and provide insights into participants' overall waste diversion practices.



By employing a combination of parametric and nonparametric tests, descriptive statistics, and correlation analysis, the research aimed to comprehensively explore and understand changes in the practice of waste diversion within the HPGOB. These statistical analyses provided a robust framework for evaluating the effectiveness of sustainability initiatives and identifying any significant shifts in waste management practices over time.

### 3.3.2. Waste Assessment

Waste assessments 1 and 2 were done in February 2019 and November 2019, respectively, to determine whether there were temporal changes in the practice of waste diversion across the study period. The waste assessment was performed based on waste sorting guidelines from the local municipality in Canada <https://www.regionofwaterloo.ca/en/waste-management.aspx>. The waste assessment was partly a waste audit process; however, we did not follow an entire waste audit process. Instead, we adopted our own waste assessment tailored to the study to measure the practice of waste diversion. Each waste assessment was performed (waste assessments 1 and 2) on waste generated across a one-week period (Monday to Friday) in the HPGOB. For each working day, the three study variables (waste diversion rate, recyclables diversion rate, and compost diversion rate) were calculated for each of the three tenant organisations and for the entire HPGOB. The waste diversion rate is expressed as a percentage and calculated as the proportion, by mass, of all waste diverted according to local municipality waste-sorting procedures to the total weight of all waste material generated.

$$\text{Waste Diversion Rate} = \frac{\text{Weight of all waste diverted}}{\text{Weight of all waste material generated}} \times 100\%$$

The recyclables diversion rate was calculated as the proportion of all materials that could be diverted except compostable materials according to the Waterloo Region sorting of waste procedure to the total weight of materials generated in recyclable and paper bins, expressed as a percentage.

$$\begin{aligned} \text{Recyclable Diversion Rate} \\ = \frac{\text{Weight of all recyclable plastic, glass, container, paper, and cardboard diverted}}{\text{the total weight waste materials generated in recyclable and paper bins}} \times 100\% \end{aligned}$$

The compost diversion rate was calculated as the proportion of all compostable materials that were diverted based on the Waterloo Region sorting of waste procedure to the total weight of materials generated in the compost bin, expressed as a percentage.

$$\text{Compost Diversion Rate} = \frac{\text{Weight of all compost diverted}}{\text{Total weight of waste materials generated in Compost Bin}}$$

The current research considers the potential diversion rate as a reference point for each waste diversion rate. As such, potential diversion rate was calculated as the total divertible materials if they were placed in the correct receptacle bin and all diverted waste materials divided by the total waste generated, expressed as a percentage.

$$\text{Potential Waste Diversion} = \frac{\text{The total divertible materials generated}}{\text{Total Waste Generated}}$$

The current research further considers a gap between the potential diversion rate and the respective waste diversion rate as an indicator of the true measurement of waste

diversion. The rate of undiverted waste is calculated by taking the difference between potential diversion rate and waste diversion rate.

$$\text{Rate of Undiverted waste} = \text{Potential Diversion Rate} - \text{Waste Diversion Rate}$$

The collected daily waste assessment data were recorded, and the respective daily diversion rates were calculated using Excel. The data were exported to SPSS for analysis. Descriptive statistics were employed to determine the mean, standard deviation, and standard error of each study variable across the tenant organisation and the entire building. Each respective waste assessment variable was also checked for parametric test assumption; each study variable showed normality and exhibited homogeneity of variance when tested for parametric test assumption.

Therefore, a parametric test was suitable to observe changes in the practice of waste diversion across waste assessments 1 and 2, for the HPGOB and tenant organisations. A paired samples t-test (Ross et al., 2017) was employed to determine whether there were changes across the practice of waste diversion (for each variable) on the entire building and within each tenant organisation. One-way ANNOVA (Heiberger et al., 2009) was also employed to explore whether there was heterogeneity of variance in the distribution of practice sustainability variables across tenant organisations. Multiple comparisons between each tenant organization's waste diversion practices were also performed using the Bonferroni post-hoc test (Wasserman, 2004) to determine where the difference lies.

To quantify the waste reduction variable, measurements were taken in kilograms to assess the waste generated across individual waste bins. This involved aggregating various waste streams, including general waste, compost, and recyclables, over the two designated time frames. Descriptive statistics were then employed to analyze waste generation for each waste stream within both the building and tenant scales of the workplace. A one-way ANOVA was utilized to discern any variations in waste generation changes among tenants A, B, and C. Additionally, trends in waste reduction practices across building and tenant scales were assessed using a paired sample t-test.

Overall, utilizing the two primary data collection methods—the survey and waste assessment—the aim was to quantify the positive temporal shift in waste diversion and waste reduction practices within a workplace context, considering both building and tenant scales. Through the examination of statistically significant changes in waste diversion and reduction practices over time, the researchers could infer a greater degree of alteration exhibited in waste diversion and reduction practices.

### 3.3.3. Sensor Data

The study collected time series data on the weight of waste in four bins – garbage, recyclables, paper, and compost – located in the common kitchen area of Tenant A. The data collection period spanned from October 2019 until February 2020. The purpose of this time series analysis was to investigate whether there was a decrease in waste generation over time.

Although the study had access to daily hourly weight recordings, it was decided to focus on the daily recordings for each bin, specifically at 8 a.m. and 5 p.m. The rationale behind this decision was to ensure that any waste removal activities conducted by cleaners or other personnel did not impact the data set. By selecting these specific times, the study aimed to capture the waste generation pattern without any interference from regular cleaning routines.

To calculate the weight of waste generated each day, the difference between the weight of waste in each receptacle bin at 5 p.m. and 8 a.m. was determined. This approach provided a measure of the waste generation for each day, considering the time interval between morning and evening.

The data were efficiently managed and stored using Grafana, an online open-source software designed for time series data visualisation and monitoring. The platform ensures data security, authentication, and access control, and its online nature enables convenient access to data from anywhere.

The time series data, covering the period from October 2019 to February 2020, were downloaded and saved in Excel format for further data cleaning and analysis. The data cleaning process involved checking for any missing values, outliers, or inconsistencies that could affect the analysis.

For the analysis, linear regression was employed to explore whether there were significant changes in waste generation over time for each receptacle bin. Linear regression allowed for the examination of the trend in waste generation and the

determination of any potential decrease or increase in waste generation over the specified period.

By conducting this time series analysis, the study aimed to gain insights into the waste generation patterns within Tenant A's common kitchen area. The findings from this analysis were intended to contribute to a better understanding of waste generation trends. An observed decline could be attributed to the display of successful waste reduction practices.

#### 3.3.4. Validity and Reliability

The triangulation of data from surveys, waste assessments, and waste disposal recordings enhanced the validity and reliability of the findings, providing a more complete understanding on the temporal shifts of waste diversion and reduction patterns of a workplace. By using multiple data collection methods, the study ensured that different perspectives and sources of information were considered, increasing the credibility and trustworthiness of the research.

In the survey, the large sample size contributes to the validity and reliability of the research. A larger sample size provides greater confidence in the findings and allows more robust statistical analysis, making the results more representative of the population and increasing the generalisability of the study.

## 4. Results

### 4.1. Descriptive Result: Survey

#### 4.1.1. Waste diversion in a workplace at HPGOB

The reported practice of waste diversion in HPGOB – measured in terms of waste diversion rate, paper/cardboard diversion rate, and plastic and glass diversion rate – was higher than 70% during the first survey. The second survey revealed a higher diversion rate (>80%) on each waste diversion variable (Table 2).

Table 2 Reported practice of waste diversion at work in HPGOB, across each survey

Study Variables	Survey	N	Mean	Std. Deviation	Std. Error Mean
Waste Diversion at Work	Wave 0	148	73.97	20.83	1.71
	Wave 1	163	84.56	18.31	1.43
Paper/Cardboard Diversion at work	Wave 0	143	82.85	20.07	1.68
	Wave 1	162	84.61	20.89	1.64
Plastic, Glass, and Container Diversion at Work	Wave 0	146	79.31	23.27	1.93
	Wave 1	159	87.84	17.45	1.38
Compost Diversion at Work	Wave 0	105	57.14	38.63	3.77
	Wave 1	156	82.59	23.53	1.88

#### 4.1.2. Reported practice of waste diversion for tenant organisations

Each tenant generally showed an increase in diversion rates for each waste diversion study variable reported during the second survey (Table 3).

Table 3 Reported practice of waste diversion for each tenant across surveys 0 and 1

	Corporates on each survey wave 0 and 1	N	Mean	Std. Deviation	Std. Error
Waste Diversion at Work	Tenant A- Wave 0	33	82.7	16.8	2.9
	Tenant A- Wave 1	44	90.4	17.2	2.6
	Tenant B- Wave 0	80	69.1	20.9	2.3
	Tenant B- Wave 1	95	81.4	19.6	2.0
	Tenant C- Wave 0	33	76.8	21.7	3.8
	Tenant C- Wave 1	26	85.8	11.7	2.3
	Total	311	79.5	20.2	1.1
Paper/Cardboard Diversion at Work	Tenant A- Wave 0	33	89.2	14.0	2.4
	Tenant A- Wave 1	44	92.1	17.4	2.6
	Tenant B- Wave 0	75	80.8	20.4	2.4
	Tenant B- Wave 1	94	81.0	21.9	2.3
	Tenant C- Wave 0	33	80.2	23.5	4.1
	Tenant C- Wave 1	26	86.2	19.1	3.7
	Total	305	83.8	20.5	1.2
Plastic, Glass, and Container Diversion at Work	Tenant A- Wave 0	33	86.7	18.9	3.3
	Tenant A- Wave 1	43	93.0	10.7	1.6
	Tenant B- Wave 0	78	76.2	23.2	2.6
	Tenant B- Wave 1	94	85.2	20.5	2.1
	Tenant C- Wave 0	33	78.0	26.4	4.6
	Tenant C- Wave 1	24	90.1	10.8	2.2
	Total	305	83.8	20.8	1.2
Compost Diversion at Work	Tenant A- Wave 0	28	71.1	37.9	7.2
	Tenant A- Wave 1	43	87.7	22.7	3.5
	Tenant B- Wave 0	46	39.0	37.1	5.5
	Tenant B- Wave 1	89	79.0	26.2	2.8
	Tenant C- Wave 0	29	73.7	29.0	5.4
	Tenant C- Wave 1	26	82.9	16.7	3.3
	Total	261	72.4	32.9	2.0

#### 4.1.3. Reported practice of waste diversion at home

Self-reported practices of waste diversion at home had a diversion rate of more than 80%, except for composting (Table 4), which showed a similar pattern with the practice



of waste diversion at work (Table 2). However, there was a decrease in reported diversion rates at home during the second survey (Table 4).

Table 4 Employees' reported practice of waste diversion at their home for each survey wave 0 and 1

Practices of waste diversion	Survey one or two		N	Mean	Std. Deviation	Std. Error Mean
Waste Diversion at home	Wave 0		144	83.7	16.9	1.41
	Wave 1		161	80.4	20.1	1.59
Paper/Cardboard Diversion at home	Wave 0		144	87.4	14.8	1.24
	Wave 1		161	83.0	19.3	1.52
Plastic, Glass, and Container Diversion at home	Wave 0		144	88.5	14.8	1.23
	Wave 1		160	84.7	18.3	1.45
Compost Diversion at home	Wave 0		104	71.5	36.2	3.55
	Wave 1		130	72.7	36.3	3.18

The survey showed a similar practice of waste diversion at home for employees working for each tenant organisation (Table 5).

Table 5 Practice of waste diversion at home for each tenant across each survey wave 0 and 1

Practice of waste diversion		N	Mean	Std. Deviation	Std. Error
Waste Diversion at home	Tenant A- Wave 0	32	88.4	15.0	2.66
	Tenant A- Wave 1	44	87.4	17.7	2.66
	Tenant B- Wave 0	78	80.3	18.4	2.08
	Tenant B- Wave 1	94	78.6	20.4	2.10
	Tenant C- Wave 0	32	86.8	13.6	2.41
	Tenant C- Wave 1	25	76.2	20.8	4.15
Paper/Cardboard Diversion at home	Tenant A- Wave 0	32	91.5	10.0	1.77
	Tenant A- Wave 1	44	89.3	14.4	2.17
	Tenant B- Wave 0	78	84.5	17.2	1.94
	Tenant B- Wave 1	94	81.0	20.5	2.11
	Tenant C- Wave 0	32	89.4	11.4	2.02
	Tenant C- Wave 1	25	80.9	20.8	4.16
Plastic, Glass, and Container Diversion at home	Tenant A- Wave 0	32	91.4	10.9	1.94
	Tenant A- Wave 1	44	86.0	15.7	2.36
	Tenant B- Wave 0	78	86.9	16.4	1.86
	Tenant B- Wave 1	94	84.2	19.5	2.01

	Tenant C- Wave 0	32	88.9	13.9	2.45
	Tenant C- Wave 1	24	85.3	18.4	3.75
Compost Diversion at home	Tenant A- Wave 0	27	81.00	32.2	6.20
	Tenant A- Wave 1	38	87.7	28.1	4.57
	Tenant B- Wave 0	56	64.8	38.8	5.18
	Tenant B- Wave 1	72	68.4	36.5	4.31
	Tenant C- Wave 0	19	76.6	32.2	7.39
	Tenant C- Wave 1	22	62.1	40.3	8.59

## 4.2. Analytic Results: Survey

### 4.2.1. Changes in practice of waste diversion (survey) across HPGOB

The analysis of self-reported waste diversion practices at work revealed differences in their distribution between survey waves 0 and 1. Specifically, the waste diversion rate, plastic and glass diversion rate, and compost diversion rate exhibited variations across the two survey waves. However, the paper/cardboard diversion rate did not show any significant difference between the survey waves. Detailed information regarding the specific distribution patterns and the comparison between survey waves can be found in Table 6 and visualised in Figures 3a, 3b, and 3c.

Table 6 Hypothesis test summary for diversion variables

Null Hypothesis	Test	Sig. <sup>a,b</sup>	Decision
The distribution of Waste Diversion at HPGOB was the same across categories of survey waves 0 and 1.	Independent-Samples Mann-Whitney U Test	<.001	Reject the null hypothesis.
The distribution of Paper/Cardboard Diversion at HPGOB is the same across	Independent-Samples Mann-Whitney U Test	0.174	Retain the null hypothesis.

categories of survey waves 0 and 1.

The distribution of Plastic and Glass Diversion at HPGOB is the same across categories of survey waves 0 and 1. Independent-Samples Mann-Whitney U Test <.001 Reject the null hypothesis.

The distribution of Compost Diversion at HPGOB is the same across categories of survey waves 0 and 1. Independent-Samples Mann-Whitney U Test <.001 Reject the null hypothesis.

<sup>a</sup> The significance level is 0.05.  
<sup>b</sup> Asymptotic significance is displayed.

The test summary of each study variable that showed statistical significance is illustrated in the figures below.

Total N	311
Mann-Whitney U	16148.500
Wilcoxon W	29514.500
Test Statistic	16148.500
Standard Error	790.296
Standardized Test Statistic	5.171
Asymptotic Sig.(2-sided test)	<.001

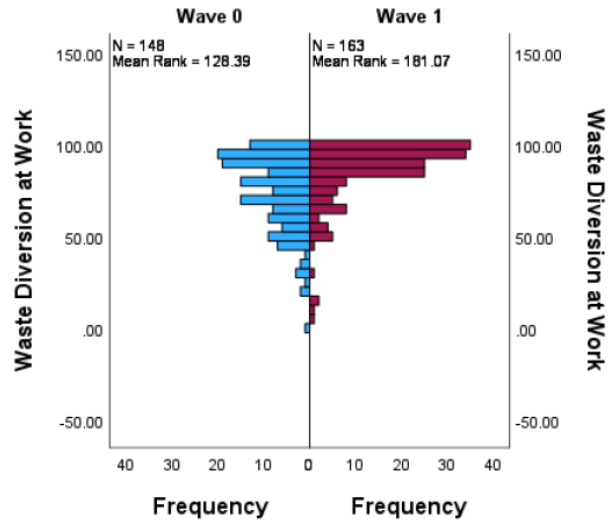


Figure 4 Independent-samples Mann-Whitney U Test Summary for Waste Diversion at HPGOB

Total N	305
Mann-Whitney U	14580.500
Wilcoxon W	27300.500
Test Statistic	14580.500
Standard Error	757.024
Standardized Test Statistic	3.928
Asymptotic Sig.(2-sided test)	<.001

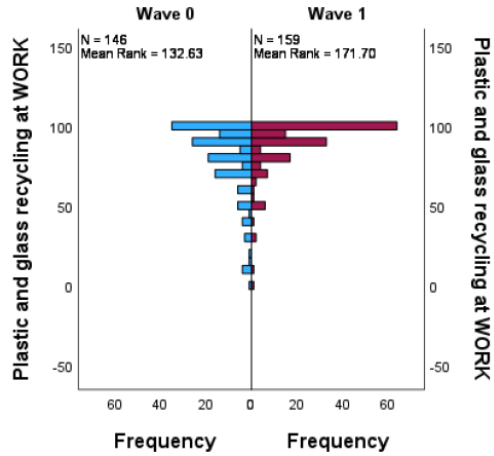


Figure 5 Independent sample Mann-Whitney U Test summary for Plastic and Glass Diversion at HPGOB.

Total N	261
Mann-Whitney U	11452.000
Wilcoxon W	23698.000
Test Statistic	11452.000
Standard Error	590.104
Standardized Test Statistic	5.528
Asymptotic Sig.(2-sided test)	<.001

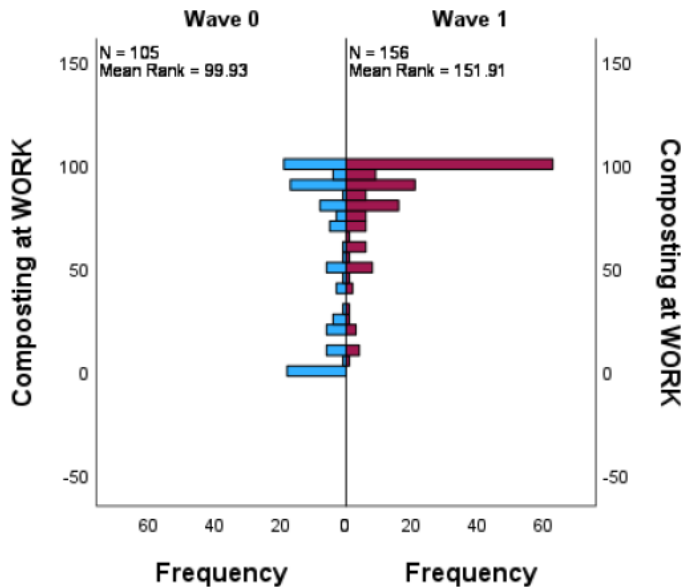


Figure 6 Independent sample Mann-Whitney U Test summary for Compost Diversion at HPGOB

#### 4.2.2. Comparison of self-reported tenants' practices of waste Diversion

The analysis of reported waste diversion practices across Tenants A, B, and C revealed significant variations between survey waves 0 and 1. The distribution of reported practices differed significantly among the tenants, as indicated in Tables 7 and 8. Notably, Tenant A and Tenant B demonstrated a substantial increase in their reported practice of waste diversion during the second survey. The specific details of the distribution patterns and the comparison between survey waves can be observed in Figure 4, which visually represents the reported practice of waste diversion for each tenant.

Table 7 Hypothesis test summary

Null Hypothesis	Test	Sig. <sup>a,b</sup>	Decision
The distribution of Waste Diversion at work was the same across Tenants A, B, and C on survey waves 0 and 1.	Independent-Samples Kruskal-Wallis Test	<.001	Reject the null hypothesis.
The distribution of Paper/Cardboard Diversion at work was the same across Tenants A, B, and C on survey waves 0 and 1.	Independent-Samples Kruskal-Wallis Test	<.001	Reject the null hypothesis.
The distribution of Plastic, Glass, and Container Diversion at work was the same across Tenants A, B, and C on survey waves 0 and 1.	Independent-Samples Kruskal-Wallis Test	<.001	Reject the null hypothesis.
The distribution of Compost Diversion at work is the same across Tenants A, B, and C on survey waves 0 and 1.	Independent-Samples Kruskal-Wallis Test	<.001	Reject the null hypothesis.

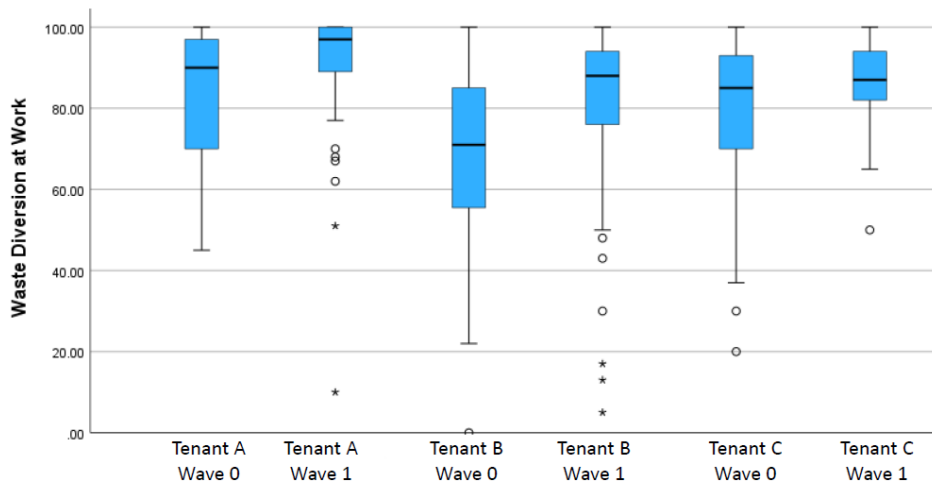
<sup>a</sup> The significance level is 0.05.

<sup>b</sup> Asymptotic significance is displayed.

Table 8 Test summary Independent-Samples Kruskal-Wallis Test

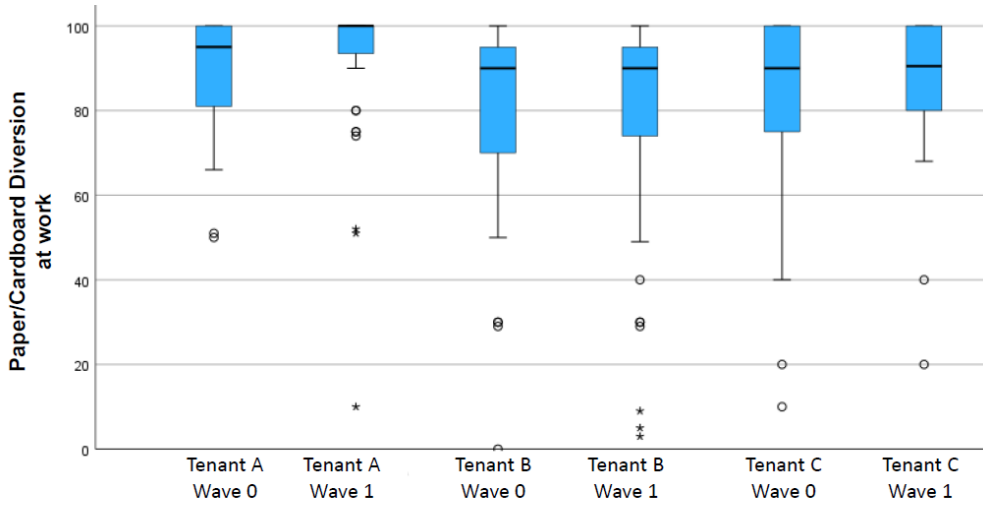
	Waste Diversion at work across each Tenant (wave 0/1)	Paper/Cardboard Diversion at work across each Tenant (wave 0/1)	Plastic, Glass, and Container Diversion at work across each Tenant (wave 0/1)	Composting Diversion at Work across each Tenant (wave 0/1)
Total N	311	305	305	261
Test Statistic	53.0 <sup>a</sup>	27.3 <sup>a</sup>	29.4 <sup>a</sup>	56.3 <sup>a</sup>
Degree of Freedom	5	5	5	5
Asymptotic Sig. (2-sided test)	<.001	<.001	<.001	<.001

a. The test statistic is adjusted for ties.



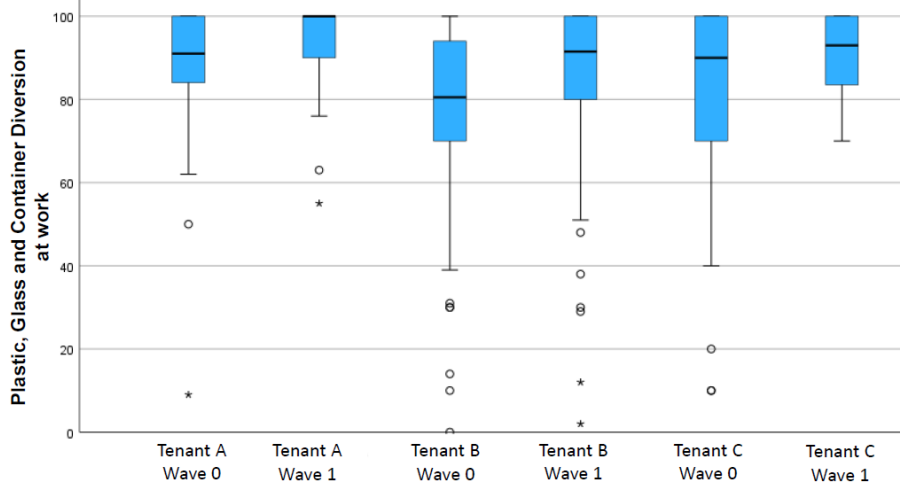
Tenants across survey wave 0 and 1

Figure 7 Waste Diversion at work: box plot test summary



Tenants across survey wave 0 and 1

Figure 8 Paper/Cardboard Diversion at work: box plot test summary



Tenants across survey wave 0 and 1

Figure 9 Plastic, Glass, and Container Diversion at work: box plot summary

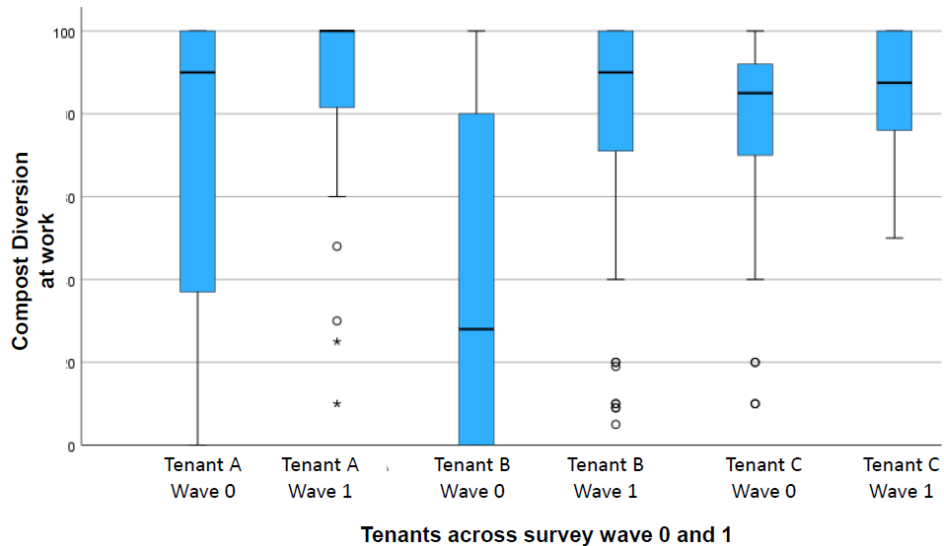


Figure 10 Compost Diversion at work: box plot test summary

The analysis of reported waste diversion practises across Tenants A, B, and C revealed significant variations between survey waves 0 and 1. The distribution of reported practices differed significantly among the tenants, as indicated in Tables 7 and 8. Tenant A and Tenant B demonstrated a substantial increase in their reported practice of waste diversion during the second survey. The specific details of the distribution patterns and the comparison between survey waves can be observed in Figure 4, which visually represents the reported practice of waste diversion for each tenant.

Table 9 Tenant A self-reported practice of waste diversion statistical test summary (across survey waves 0 and 1)

	Waste Diversion at work	Paper/Cardboard Diversion at work	Plastic, Glass, and Container Diversion at work	Compost Diversion at work
Mann-Whitney U	458	515	534	423
Wilcoxon W	1019	1076	1095	829
Z	-3	-2	-2	-2
Asymp. Sig. (2-tailed)	<0.001	<0.001	<0.001	<0.001



Table 10 Tenant B self-reported practice of waste diversion statistical test summary (across survey waves 0 and 1)

	Waste Diversion at work	Paper/Cardboard Diversion at work	Plastic, Glass, and Container Diversion at work	Compost Diversion at work
Mann-Whitney U	2297	3400	2534	790
Wilcoxon W	5537	6250	5615	1871
Z	-5	0	-4	-6
Asymp. Sig. (2-tailed)	<.001	.691	<.001	<.001

Table 11 Tenant C self-reported practice of waste diversion statistical test summary (across survey waves 0 and 1)

	Waste Diversion at work	Paper/Cardboard Diversion at work	Plastic, Glass, and Container Diversion at work	Compost Diversion at work
Mann-Whitney U	339.50	369.50	308.50	320.5
Wilcoxon W	900.50	930.50	869.50	755.5
Z	-1.37	-0.92	-1.44	-0.96
Asymp. Sig. (2-tailed)	0.17	0.36	0.15	0.34

#### 4.2.3. Changes in reported practice of waste diversion at home on survey waves 0 and 1

Self-reported practice of waste diversion at “employee’s home” did not show significant changes (Table 12).

Table 12 Hypothesis test summary

Null Hypothesis	Test	Sig. <sup>a</sup>	Decision
The distribution of Waste Diversion at home was the same across categories of survey waves 0 and 1.	Independent-Samples Mann-Whitney U Test	0.502	Retain the null hypothesis.

The distribution of Paper/Cardboard Diversion at home is the same across categories of survey waves 0 and 1.	Independent-Samples Mann-Whitney U Test	0.328	Retain the null hypothesis.
The distribution of Plastic and Glass Diversion at home was the same across categories of survey waves 0 and 1.	Independent-Samples Mann-Whitney U Test	0.128	Retain the null hypothesis.
The distribution of Compost Diversion at home was the same across categories of survey waves 0 and 1.	Independent-Samples Mann-Whitney U Test	0.342	Retain the null hypothesis.

a. The significance level is 0.05.

#### 4.2.4. Relationship between diversion variables at home and workplace

Spearman's rank correlation coefficient was calculated to examine the relationship between the diversion variables at home and in the workplace across survey waves 0 and 1. The analysis revealed a significant positive correlation between the respective diversion variables at home and at work. The specific correlation coefficients and the visual representation of this relationship can be found in Figures 11 and 12.

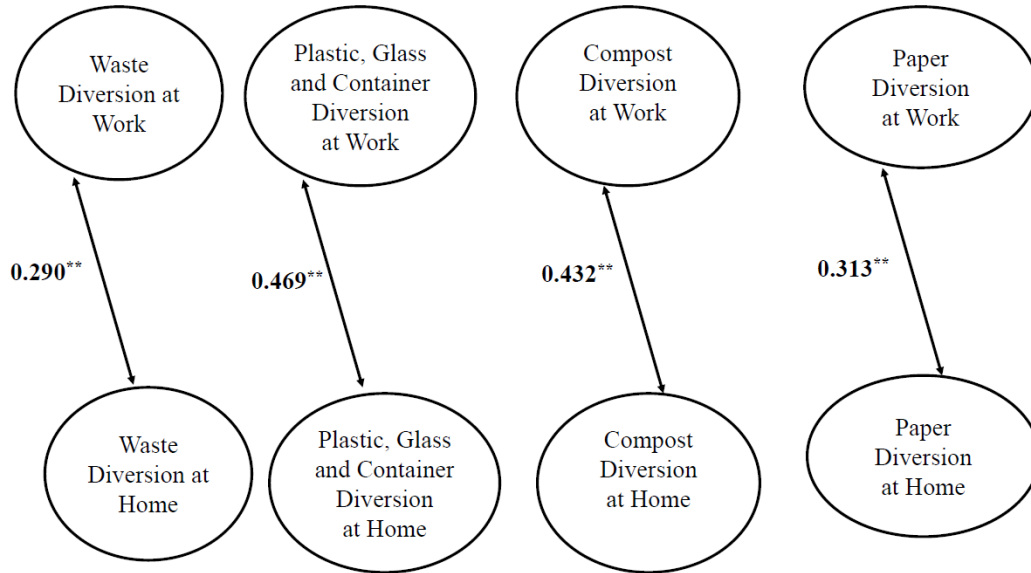


Figure 11 Spearman's Rank Correlation on the respective diversion variables at home and work for *Survey wave 0*

\*\* Correlation is highly significant at the 0.01 level (2-tailed)

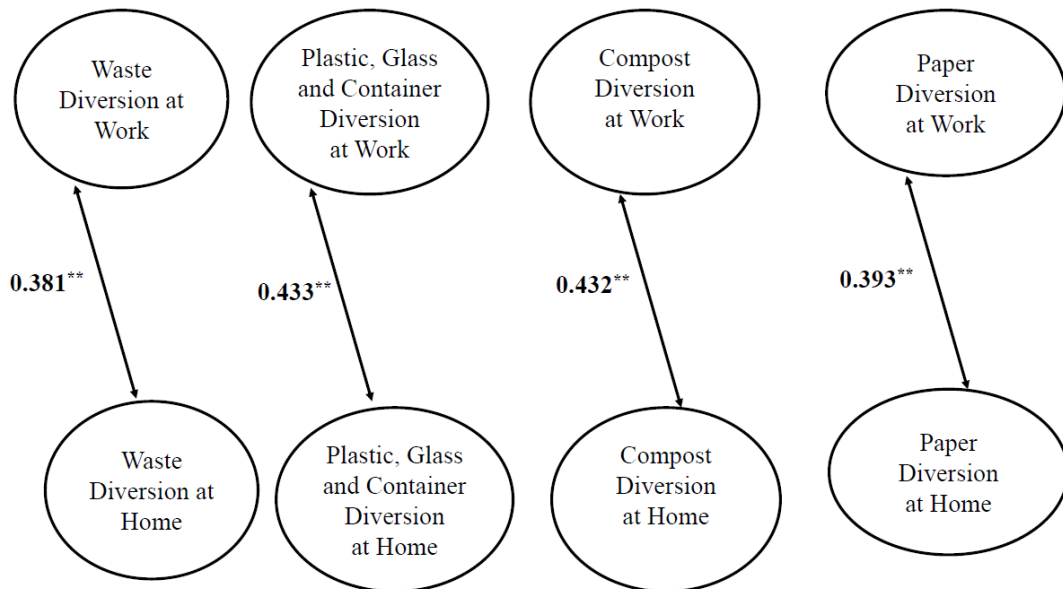


Figure 12 Spearman's Rank Correlation on the respective diversion variables at home and work for *survey wave 1*

\*\* Correlation is highly significant at the 0.01 level (2-tailed)

### 4.3. Descriptive Result: Waste Assessment

In the descriptive analysis of waste assessment for the HPGOB, the results indicated a decrease in the rate of undiverted waste during waste assessment 2 compared to waste assessment 1. This suggests an improvement in waste diversion practices over time because a lower rate of undiverted waste indicates a higher proportion of waste being successfully diverted. Furthermore, the recyclable diversion rate was relatively low compared to the compost diversion rate.

Table 13 Practice of waste diversion across waste assessments 1 and 2 at HPGOB

Study Variable	HPGOB	N	Mean (%)	Std. Deviation	Std. Error Mean
Waste Diversion Rate	Waste assessment 1	5	64.4	3.13	1.40
	Waste assessment 2	5	72.6	3.36	1.50
Recyclable Diversion rate	Waste assessment 1	5	40.8	4.92	2.20
	Waste assessment 2	5	38.4	4.77	2.14
Compost Diversion Rate	Waste assessment 1	5	51.2	3.70	1.66
	Waste assessment 2	5	62.8	2.39	1.07
Rate of Undiverted Waste	Waste assessment 1	5	20.2	8.76	3.92
	Waste assessment 2	5	8.00	1.22	0.55

Table 14 Tenants' practice of waste diversion across waste assessments 1 and 2

Study Variables	Tenant and W. assessment	N	Mean (%)	Std. Deviation	Std. Error
Waste Diversion Rate	Tenant A W. Assessment 1	5	71.4	5.64	2.52

	Tenant A W. Assessment 2	5	67.0	2.74	1.22
	Tenant B W. Assessment 1	5	44.6	5.46	2.44
	Tenant B W. Assessment 2	5	64.6	5.68	2.54
	Tenant C W. Assessment 1	5	74.2	1.92	0.86
	Tenant C W. Assessment 2	5	80.8	4.60	2.06
Recyclable Diversion Rate	Tenant A W. Assessment 1	5	61.8	16.19	7.24
	Tenant A W. Assessment 2	5	58.6	5.32	2.38
	Tenant B W. Assessment 1	5	61.4	14.74	6.59
	Tenant B W. Assessment 2	5	59.8	5.67	2.54
	Tenant C W. Assessment 1	5	45.4	14.54	6.50
	Tenant C W. Assessment 2	5	41.6	8.02	3.59
Compost Diversion Rate	Tenant A W. Assessment 1	5	69.2	3.35	1.50
	Tenant A W. Assessment 2	5	65.0	4.85	2.17
	Tenant B W. Assessment 1	5	32.0	9.03	4.04
	Tenant B W. Assessment 2	5	43.0	9.54	4.27
	Tenant C W. Assessment 1	5	71.0	4.36	1.95
	Tenant C W. Assessment 2	5	79.2	4.66	2.08
Rate of Undiverted Waste	Tenant A Waste Assessment 1	5	14.4	4.04	1.81
	Tenant A Waste Assessment 2	5	3.00	3.39	1.52
	Tenant B Waste Assessment 1	5	33.0	13.57	6.07
	Tenant B Waste Assessment 2	5	9.40	5.55	2.48
	Tenant C Waste Assessment 1	5	11.4	7.83	3.50
	Tenant C Waste Assessment 2	5	8.60	3.05	1.36

Table 15 Each waste stream generated across each tenant and entire HPGOB measured in kilograms (kg)

		N	Mean (Kg)	Std. Deviation	Std. Error
Garbage Generate d (Kg)	Tenant A Waste Assessment 1	5	1.23	0.38	0.17
	Tenant A Waste Assessment 2	5	2.21	1.13	0.51
	Tenant B Waste Assessment 1	5	5.42	2.94	1.32
	Tenant B Waste Assessment 2	5	4.13	1.33	0.60
	Tenant C Waste Assessment 1	5	2.58	1.21	0.54
	Tenant C Waste Assessment 2	5	2.87	1.44	0.64
	HPGOB Waste Assessment 1	5	9.22	4.32	1.93

	HPGOB Waste Assessment 2	5	9.21	2.88	1.29
Recyclable Generated (Kg)	Tenant A Waste Assessment 1	5	5.69	2.01	0.90
	Tenant A Waste Assessment 2	5	2.60	0.92	0.41
	Tenant B Waste Assessment 1	5	10.00	1.35	0.60
	Tenant B Waste Assessment 2	5	6.33	2.65	1.19
	Tenant C Waste Assessment 1	5	5.27	1.95	0.87
	Tenant C Waste Assessment 2	5	4.57	2.98	1.33
	HPGOB Waste Assessment 1	5	20.96	3.44	1.54
	HPGOB Waste Assessment 2	5	13.51	5.74	2.57
Compost Generated (Kg)	Tenant A Waste Assessment 1	5	4.47	2.09	0.93
	Tenant A Waste Assessment 2	5	4.16	1.11	0.49
	Tenant B Waste Assessment 1	5	7.26	1.57	0.70
	Tenant B Waste Assessment 2	5	7.66	2.01	0.90
	Tenant C Waste Assessment 1	5	10.76	3.66	1.64
	Tenant C Waste Assessment 2	5	18.31	8.40	3.76
	HPGOB Waste Assessment 1	5	22.48	2.69	1.21
	HPGOB Waste Assessment 2	5	30.13	10.26	4.59

#### 4.4. Analytical Results: Waste Assessment

##### 4.4.1. Practice of waste diversion at HPGOB across waste assessments 1 and 2

Table 16 Changes in practice of waste diversion at HPGOB; paired sample t test on Waste Assessment 1 and 2

	Paired Differences						t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Lower	Upper				
Waste Diversion Rate WA1 - Waste Diversion Rate WA 2	-8.20	4.92	2.20	-14.31	-2.09	-3.73	4	0.02	
Recyclable Diversion Rate WA1 - Recyclable Diversion Rate WA 2	2.40	7.67	3.43	-7.12	11.92	0.70	4	0.52	

Compost Diversion Rate WA1 - Compost Diversion Rate WA2	-11.60	5.64	2.52	-18.60	-4.60	-4.60	4.00	0.01
Rate of Undiverted waste WA1 - Rate of Undiverted waste WA2	12.20	9.81	4.39	0.02	24.38	2.78	4	0.05

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Significance level  $P < 0.05$

#### 4.4.2. Waste diversion practice of tenant organisations across waste assessments 1 and 2

Table 17 Comparison of waste diversion practice between Tenants A, B, and C on Waste Assessment 1: a one-way ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Waste Diversion Rate	Between Groups	2670.40	2	1335.20	61.34	0.00
	Within Groups	261.20	12	21.77		
	Total	2931.60	14			
Recyclable Diversion Rate	Between Groups	875.20	2	437.60	1.90	0.19
	Within Groups	2763.20	12	230.27		
	Total	3638.40	14			
Compost Diversion Rate	Between Groups	4846.80	2	2423.40	65.09	0.00
	Within Groups	446.80	12	37.23		
	Total	5293.60	14			
Rate of Undiverted Waste	Between Groups	1369.20	2	684.60	7.85	0.01
	Within Groups	1046.40	12	87.20		
	Total	2415.60	14			

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Significance level  $P < 0.05$

Table 18 Comparison of waste diversion practice computed across Tenants A, B, and C on Waste Assessment 2: a one-way ANOVA.

		Sum of Squares	df	Mean Square	F	Sig.
Waste Diversion Rate	Between Groups	764.40	2	382.20	18.80	0.00
	Within Groups	244.00	12	20.33		
	Total	1008.40	14			
Recyclable Diversion Rate	Between Groups	1036.13	2	518.07	12.45	0.00
	Within Groups	499.20	12	41.60		
	Total	1535.33	14			
Compost Diversion Rate	Between Groups	3326.80	2	1663.40	36.64	0.00
	Within Groups	544.80	12	45.40		
	Total	3871.60	14			
Rate of Undiverted waste	Between Groups	360.53	2	180.27	10.79	0.00
	Within Groups	200.40	12	16.70		
	Total	560.93	14			

#### 4.4.3. Changes in practice of waste diversion across each tenant

Table 19 Changes in Tenant A's practice of waste diversion: a paired sample t test on Waste Assessments 1 and 2

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Waste Diversion Rate WA 1 - Waste Diversion WA 2	4.40	7.20	3.22	-4.54	13.34	1.37	4	0.24



Pair 2	Recyclable Diversion Rate WA 1 - Recyclable Diversion WA 2	3.20	15.58	6.97	-16.14	22.54	0.46	4	0.67
Pair 3	Compost Diversion Rate WA 1 - Compost Diversion WA 2	4.20	2.77	1.24	0.75	7.65	3.38	4	0.03
Pair 4	Rate of Undiverted Waste WA1 - Rate of Undiverted waste WA2	11.40	5.18	2.32	4.97	17.83	4.92	4	0.01

Significance level  $P < 0.05$

Table 20 Changes in Tenant B's practice of waste diversion: a paired sample t test on Waste Assessments 1 and 2

		Paired Differences					t	df	Sig. (2- tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Waste Diversion Rate WA 1 - Waste Diversion WA 2	- 20.00	10.42	4.66	-32.93	-7.07	-4.29	4	0.01
Pair 2	Recyclable Diversion Rate WA1 - Recyclable Diversion WA 2	1.60	18.15	8.12	-20.93	24.13	0.20	4	0.85
Pair 3	Compost Diversion Rate WA1 - Compost Diversion Rate WA 2	- 11.00	16.05	7.18	-30.92	8.92	-1.53	4	0.20

Pair 4	Rate of Undiverted waste WA1 - Rate Undiverted waste WA2	23.60	18.24	8.16	0.95	46.25	2.89	4	0.04
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Significance level P < 0.05

Table 21 Changes in Tenant C's practice of waste diversion: a paired sample t test across Waste Assessments 1 and 2

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Waste Diversion Rate WA 1 - Waste Diversion Rate WA 2	-6.60	3.36	1.50	-10.77	-2.43	-4.39	4	0.01
Pair 2	Recyclable Diversion Rate WA1 - Recyclable Diversion Rate WA 2	3.80	9.18	4.10	-7.59	15.19	0.93	4	0.41
Pair 3	Compost Diversion Rate WA1 - Compost Diversion Rate WA 2	-8.20	8.84	3.95	-19.18	2.78	-2.07	4	0.11
Pair 4	Rate of Undiverted waste WA1 - Rate of Undiverted waste WA2	2.80	6.65	2.97	-5.45	11.05	0.94	4	0.40

Significance level P < 0.05

Table 22 Changes in waste reduction practice across Tenant and HPGOB level

			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Dev	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
Tenant A	Pair 1	Garbage (WA1-WA2)	0.37	0.25	0.11	0.05	0.68	3.22	4	0.03
	Pair 2	Recyclable (WA1-WA2)	3.49	2.49	1.11	0.40	6.58	3.14	4	0.04
	Pair 3	Compost (WA1-WA2)	2.31	1.64	0.73	0.27	4.34	3.14	4	0.04
Tenant B	Pair 1	Garbage (WA1-WA2)	2.59	2.50	1.12	-0.52	5.70	2.31	4	0.08
	Pair 2	Recyclable (WA1-WA2)	6.27	2.16	0.97	3.58	8.95	6.48	4	0.00
	Pair 3	Compost (WA1-WA2)	2.80	0.51	0.23	2.16	3.44	12.19	4	0.00
Tenant C	Pair 1	Garbage (WA1-WA2)	-0.29	0.95	0.43	-1.47	0.89	-0.68	4	0.54
	Pair 2	Recyclable (WA1-WA2)	0.70	4.05	1.81	-4.33	5.72	0.38	4	0.72
	Pair 3	Compost (WA1-WA2)	-7.55	10.10	4.52	-20.09	4.98	-1.67	4	0.17
HPGOB	Pair 1	Garbage (WA1-WA2)	0.01	3.07	1.37	-3.80	3.83	0.01	4	0.99
	Pair 2	Recyclable (WA1-WA2)	7.45	7.82	3.50	-2.26	17.16	2.13	4	0.10
	Pair 3	Compost (WA1-WA2)	-7.64	11.59	5.18	-22.03	6.74	-1.48	4	0.21

Significance level  $P < 0.05$

Table 13 Difference exist on changes in waste reduction practices across Tenant A, B and C

		Sum of Squares	df	Mean Square	F	Sig.
Garbage Generated (Kg)	Between Groups	338.57	7.00	48.37	9.14	0.00
	Within Groups	169.42	32.00	5.29		
	Total	507.99	39.00			
	Between Groups	1278.91	7.00	182.70	20.53	0.00

Recyclables Generated (Kg)	Within Groups	284.77	32.00	8.90		
	Total	1563.68	39.00			
	Between Groups	3143.70	7.00	449.10	17.21	0.00
Compost Generated (Kg)	Within Groups	835.00	32.00	26.09		
	Total	3978.70	39.00			

Significance level  $P < 0.05$

#### 4.5. Sensor data: a time series weight data analysis

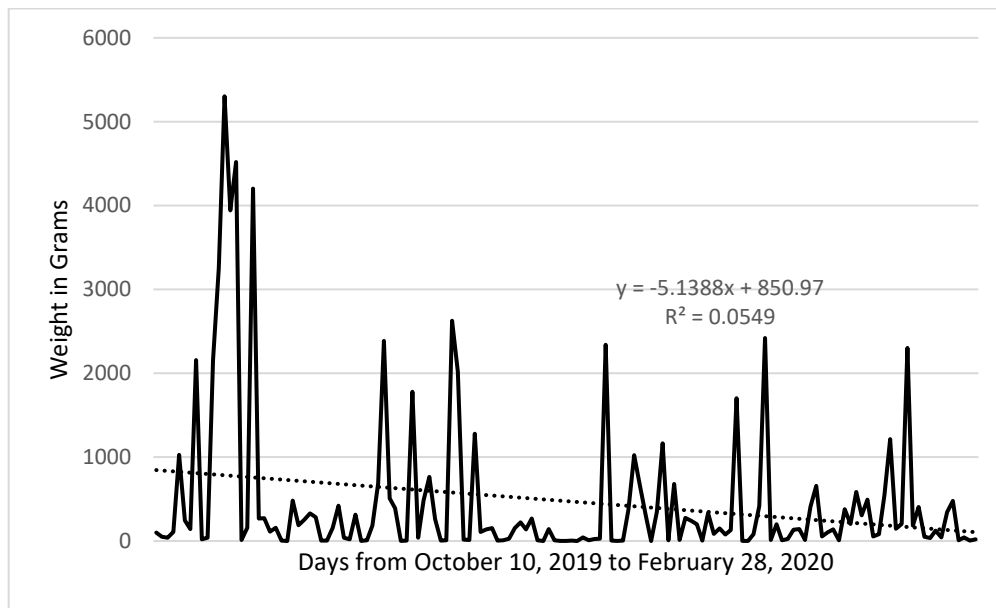


Figure 11 Changes over time on waste generated at Garbage waste bin in Tenant A's Kitchen

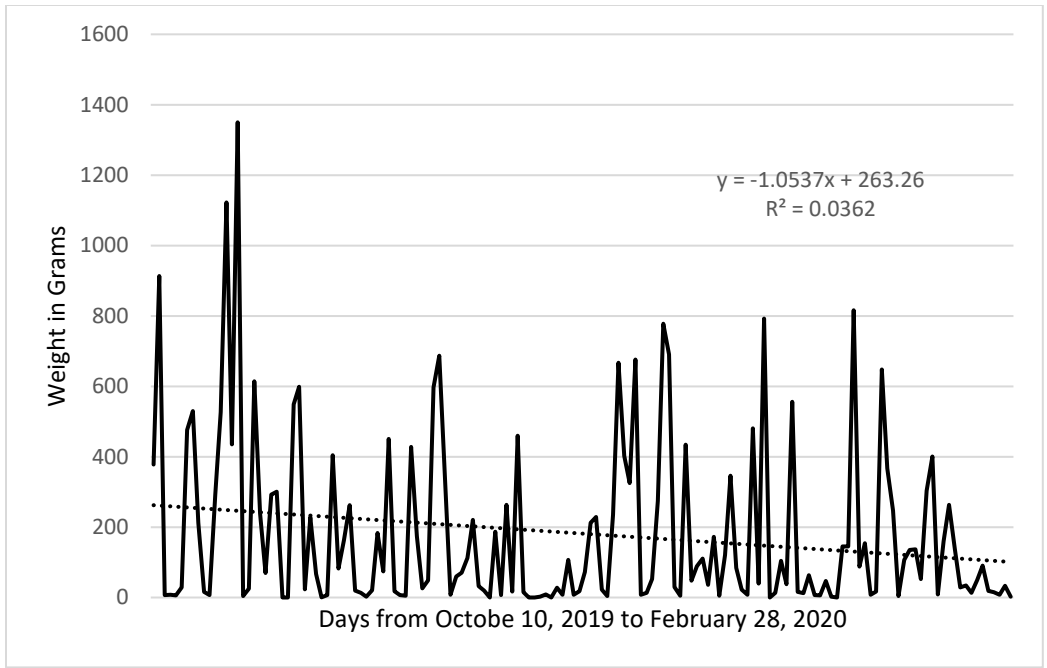


Figure 12 Changes over time on waste generated at Recyclables Bin of Tenant A's Kitchen

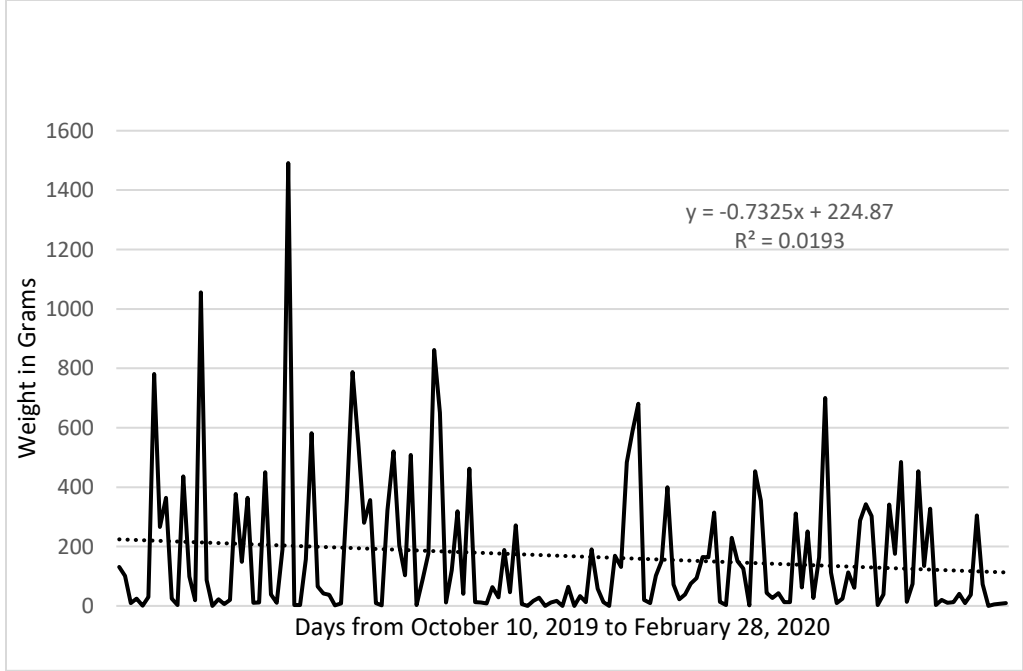


Figure 13 Changes over time on waste generated at Paper Bin of Tenant A's Kitchen

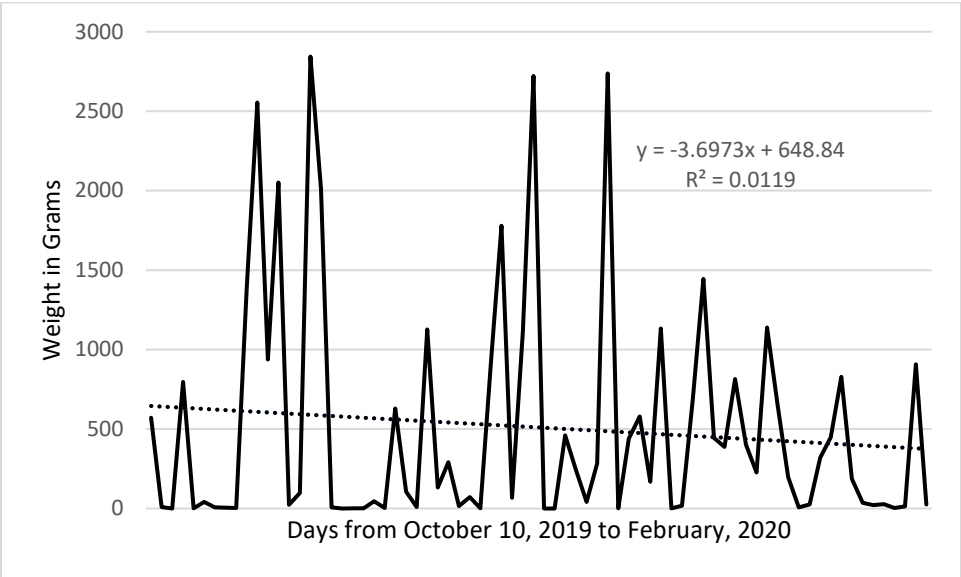


Figure 14 Changes over time on waste generated at Compost Bin of Tenant A's Kitchen

## 5. Discussion

The study explored how the social practice of waste diversion and reduction evolves over time within a workplace. Initially, the researchers hypothesised waste diversion and reduction practice could be shaped building and tenant scales of a workplace. The findings revealed that the social practice of waste diversion and reduction transformed over time, encompassing both tenant and building scales within the workplace. tenants exhibited distinct patterns of change in their waste diversion and reduction practices.

One could make the case that waste management practices generally yielded favourable results at the building level. In terms of individual tenants, Tenant A and Tenant B exhibited relatively robust shifts in both waste diversion and reduction practices. This divergence could potentially be attributed to differences in the social and material structures specific to each tenant's workplace. This finding emphasised the importance of considering scale when studying environmental sustainability practices. In this context, the concept of “scale” refers to the level at which environmental sustainability practices are observed and measured. In the case of the workplace, the scale can be viewed at the individual tenant level or the broader building level. The variability in the extent of change among tenants implies that waste management practices may differ across tenants due to the distinct social and material structures within their respective organisations.

### 5.1. Exploring Workplace Waste Diversion and Reduction Practices: Insights from Survey, Waste Assessment and Sensor Data Sets

The survey and waste assessment data sets provided valuable insights into the practice of waste diversion at both building and tenant scales. Although there was general congruence between the two data sets in supporting positive changes in waste diversion, it is important to discuss the results based on each data set because not all variables and findings were entirely consistent.

The survey results indicated that waste diversion variables – except paper/cardboard diversion – showed a statistically significant change across the building scale. This suggests that there has been a positive shift in waste diversion practices within the building. However, the findings from the waste assessment painted a slightly different picture. The recyclable diversion rate did not show a statistically significant increase at HPGOB, as indicated in Table 15. This discrepancy could be attributed to the fact that paper/cardboard materials were considered recyclable when calculating the recyclable diversion rate for the waste assessment data set.

Another notable observation is that HPGOB showed an increase in waste diversion rate during the second waste assessment, leading to a reduced rate of undiverted waste (Table 15). This change may be attributed to the compost bin receiving a significant proportion of compostable waste materials compared to other waste streams. During the waste assessment, it was noticed that a comparatively large amount of unsorted



leftover foods, along with plastic forks and unrecyclable lunch packages, were disposed of in the compost bin at Tenant C's workplace. This contributed to an increase in the compost diversion rate, which, in turn, decreased the rate of undiverted waste. It is worth mentioning that a high disposal rate of food waste could further impact the calculation of the compost diversion rate and the rate of undiverted waste. As mentioned in the previous section, Tenant C's policy on eating and food choices significantly influenced the amount of food waste generated, resulting in a high volume of compost. Therefore, assessing waste diversion practices solely based on the weight of waste streams may not provide an accurate representation of the material element of social waste diversion practices. Periods of monitoring of waste generation could help fill this gap and provide insights into the trend of waste generation, which is a crucial material aspect of the social practice of waste diversion and reduction (Foulds et al., 2013).

Despite the limitations of waste assessment in capturing the materiality of waste diversion practice, this research considers the "rate of undiverted waste" as an additional variable for measuring waste diversion practice. Other variables computed in waste assessment methodologies, such as the waste diversion rate, may not fully inform the true extent of waste diversion. The extent of waste diversion depends not only on the amount of divertible waste generated – such as paper, glass, containers, cardboard, and compostable materials – but also on the waste materials that cannot be diverted. The waste diversion rate alone does not provide comprehensive information about the amount of divertible waste that remains unsorted and should have been

diverted. Therefore, the “rate of undiverted waste” was calculated by subtracting the waste diversion rate from the potential diversion rate to indicate a relatively accurate measure of waste diversion. For instance, the survey data set revealed that Tenant A showed a significant change in waste diversion across all variables. However, when the waste assessment data set was examined, the change in the waste diversion rate was not statistically significant. Nevertheless, the changes in the “rate of undiverted waste” for Tenant A were highly significant. Therefore, the “rate of undiverted waste” is considered a more reliable measure of the social practice of waste diversion.

One important insight drawn from the waste assessment data spanning two distinct periods is the measurement of waste generation, which serves as a crucial indicator for assessing waste reduction practices. Notably, Tenants A and B exhibited significant and positive changes in their waste diversion practices. This trend aligns cohesively with waste diversion practices measured through both the survey and the waste assessment data. The convergence of findings from multiple data sources lends robustness to our observations.

In contrast, Tenant C's waste reduction practice did not demonstrate a comparable positive trajectory. This outcome aligns with the survey data, which also indicated an insignificant change in waste diversion practices for Tenant C. This consistent pattern between the survey data and the waste assessment data reinforces the validity of our assessments. However, when we shift our focus to the building-wide perspective using the waste assessment data, a distinct pattern emerges. Here, the waste reduction

practices did not display a positive shift. This divergence from the individual tenant data calls for a closer examination of underlying factors.

One potential explanation for this divergence could be the disproportionately higher contribution of Tenant C to the overall waste generation, particularly in specific waste streams, notably compost. This substantial increase in waste generation, especially in compost, may have overshadowed collective waste reduction efforts within the building, thereby contributing to the absence of a positive shift in waste reduction practices at the building scale. In essence, while Tenants A and B made commendable progress in their waste diversion practices, Tenant C's trajectory remained relatively stagnant. This phenomenon is mirrored in both survey data and waste assessment findings. However, a broader perspective offered by the building's waste assessment data sheds light on the potential influence of individual tenant contributions on the collective waste reduction landscape. This multifaceted analysis underscores the intricacies of waste management within a multi-tenant building and underscores the importance of considering both individual and collective factors in designing effective waste reduction strategies. In summary, both the survey and waste assessment data sets contribute valuable insights into understanding waste diversion practices. While they generally support positive changes in these practices, some discrepancies arise between the two data sets, particularly concerning the recyclable diversion rate. To better grasp the material aspects of waste diversion, incorporating daily waste generation monitoring alongside the weight-based waste assessment approach is essential. Furthermore, the "rate of undiverted waste" emerges as a meaningful variable for measuring the genuine

extent of waste diversion, accounting for both divertible waste generation and non-divertible waste materials. By considering multiple variables and acknowledging the limitations of various data sets, we can attain a more comprehensive understanding of waste diversion practices.

Moreover, the waste assessment data sheds light on the significance of measuring waste generation when evaluating waste reduction practices. Tenants A and B demonstrate positive changes in waste diversion, substantiated by multiple data sources. In contrast, Tenant C's stagnant waste reduction aligns with the survey data, possibly attributed to the building level higher waste contribution. This underscores the intricate nature of waste management and emphasizes the necessity of considering both individual and collective factors when striving to reduce waste.

The third data set, which measures the periods of waste generation across each waste bin, reveals a notable trend of decreasing waste generation. This finding is in line with the positive changes observed in the social practice of workplace environmental sustainability (WES) among Tenant A. However, it is important to note that the  $R^2$  values associated with each trend line are relatively small, indicating that the data does not fit well with a linear trend line.

The relatively small  $R^2$  values associated with the trend lines suggest that the data does not fit well with a linear trend. This finding implies that waste generation patterns may be influenced by various factors that are not captured by a simple linear relationship. It is

important to consider other variables and factors that could affect waste generation, such as the type of work and other activities that differs in time associated waste generation, workforce size, or seasonal variations.

To gain a more comprehensive understanding of waste generation patterns, future research should explore additional factors that may contribute to the observed trends. This could involve considering qualitative data or conducting interviews or surveys to identify potential drivers of waste reduction. Furthermore, analysing the data over a longer period or collecting data from multiple sources could provide a more robust assessment of waste generation trends.

While there are limitations to using a linear trend line to model the data, it's noteworthy that the decreasing trend in waste generation evident in the third dataset aligns with Tenant A's dedicated efforts to promote workplace environmental sustainability, particularly in the realm of waste reduction initiatives. It is crucial to maintain continuous and comprehensive analysis of waste generation trends to accurately assess the long-term effectiveness of waste reduction practices and identify areas where further improvements can be made.

## 5.2. Resemblance of the social practice of waste diversion at work and home

The current study found that the relationship between waste diversion practices at work and at employees' homes, suggesting the possibility of a spillover effect. The "spillover effect" (Geiger, 2022) refers to the notion that waste diversion practice in the workplace could extend to employees' behaviours in their personal lives at home. By exploring this phenomenon, the study draws on social practice theory, which asserts that the performance of a particular practice in different contexts should exhibit similarities (Nash et al., 2017; Wonneck & Hobson, 2017).

The survey data analysis uncovered a significant correlation between waste diversion variables in both workplace and employees' residences, as visualized in Figures 11 and 12. This intriguing finding implies that there might be a notable similarity between how waste diversion practices are carried out in the workplace and those adopted within employees' domestic settings. This correlation hints at the possibility of a shared social practice of waste diversion that transcends the boundaries of the workplace and extends into employees' homes, highlighting the potential interconnectedness of these two domains in promoting waste diversion practices.

However, an intriguing revelation surfaced when examining the survey data longitudinally. While waste diversion practices at the workplace exhibited noticeable changes, indicative of successful implementation waste diversion practices, a different pattern emerged when looking at waste diversion at home. The researchers noted that

the social practice of waste diversion at home remained relatively stable over time, as evidenced by the data presented in Table 12.

This observation raises questions about the extent to which the social practice of waste diversion at work is being transferred to employees' homes. To gain a deeper understanding, it becomes necessary to examine the underlying factors that shape waste diversion practices in the home context. This analysis requires tracing the elemental framework of the social practice of waste diversion at home and exploring why it did not undergo significant changes.

Possible explanations for this lack of change could include differences in contextual factors between the workplace and home settings. It is plausible that the workplace environment provides specific cues and social norms that facilitate waste diversion while such factors may not be as prominent or effectively translated to the home context. Furthermore, individual motivations and constraints in a home environment may vary, potentially impacting the adoption of waste diversion practices that extend beyond the workplace.

In conclusion, the study argues for the existence of a spillover effect, suggesting that the social practice of waste diversion at work could potentially influence waste diversion

behaviours at employees' homes. Although a strong correlation was found between workplace and home waste diversion practices, the study also revealed the stagnation of waste diversion practices at home over time. To bridge this gap, further investigation

is needed to understand the contextual and individual factors that hinder the transferability of environmental sustainability practices. By identifying and addressing these barriers, it becomes possible to establish a waste management strategy that extends beyond the workplace and permeates into employees' homes.

### 5.3. Understanding the changes in waste diversion and reduction practice using the lens of Social Practice Theory

It can also be argued that the pronounced enhancements in the social practice of waste diversion and reduction, as observed in the case of Tenant B, can be attributed to its corporate culture's commitment to sustainability. Upon closer examination, anecdotal evidence pertaining to Tenant B underscores the centrality of sustainability within its strategic mission. This commitment manifested through concrete actions, such as the adoption of paperless organizational processes, the establishment of a dedicated sustainability advisory group, the empowerment of its employees in Waterloo to actively engage clients in sustainability initiatives, the dissemination of sustainability-focused knowledge to other branches, and the expansion of its business model to actively support environmental initiatives. This robust commitment to sustainability could highlight the potential influence of corporate culture in shaping waste management practices within the workplace.



In the case of Tenant A, which houses partner organizations, anecdotal information reveals that these entities espouse a robust commitment to sustainability and actively strive to embody these principles in their operations. Among the organizations within Tenant A, one entity, serving as a community intermediary, emerged as a significant catalyst in shaping and championing a collective vision focused on sustainability. This organization has played a pivotal role in not only conceptualizing but also spearheading collaborative efforts aimed at transforming the workplace into a net-zero carbon building, with the overarching objective of substantially diminishing the overall carbon emissions footprint of the workplace (Reimer et al., 2021). workplace.

Tenant C displayed a somewhat cautious stance when it came to aligning with the overarching sustainability vision of the workplace. Limited information is available regarding this tenant's concrete demonstration of sustainability in its operational practices and strategic mission. In fact, such evidence was not readily discernible on the tenant's organizational website. Therefore, the varying social and cultural orientations toward sustainability among the respective tenant organisations could account for the differences in their ability to change and reshape unsustainable practices.

However, it is essential to recognize that various other factors, apart from the organizational culture and commitment mentioned earlier, can play a substantial role in shaping an organization's capacity to successfully implement sustainability initiatives. Among these factors, the organization's size, its hierarchical structure, and the specific industry it operates in are noteworthy.

Research by Kiesnere and Baumgartner (2019), Ordonez-Ponce et al. (2021), Samuel and Clarke (2022), and Siebenhüner and Arnold (2007) has shown that the size of an organization can significantly impact its ability to embrace sustainability practices. Larger organizations may have more extensive resources and greater capacity to invest in sustainability initiatives, while smaller ones might face resource constraints and scalability challenges.

Furthermore, the hierarchical structure within an organization can affect the ease with which sustainability initiatives are adopted and integrated into day-to-day operations. Hierarchical structures that facilitate communication and decision-making related to sustainability may be better positioned to implement these initiatives effectively.

Lastly, the sector or industry in which an organization operates can also be a critical factor. Some industries may inherently lend themselves to more sustainable practices, while others may face unique challenges or regulatory hurdles in pursuing sustainability goals.

Taken together, these factors underscore the complexity of sustainability implementation within organizations, highlighting that a holistic understanding of an organization's context and characteristics is essential when assessing its capacity to engage in sustainable practices.

The current research highlights the possibility of understanding how the social practice of waste diversion patterns is reshaped at both tenant organisations and building

workplaces using the lens of social practice theory (SPT) (Shove et al., 2012). This reshaping is attributed to changes in the elemental frameworks of social practice, which include socially shared meanings, competency, and materiality (Keegan & Breadsell, 2021; Southerton & Yates, 2014).

It is crucial to acknowledge that these three elements of waste diversion practice could be influenced by social, cultural, and physical structures at both tenant organisation and building workplace scales. It is important to note that these elements are interconnected and do not possess clear boundaries in relation to one another (Røpke, 2009).

Furthermore, because workplaces are shared across tenant organisations, defining clear boundaries between tenant organisations, and building workplaces can be challenging.

Considering these factors, the following subsections discuss how each of the three elements of waste diversion and reduction practice is influenced by efforts to co-create a culture of sustainability at both tenant and organisational scales.

The element of socially shared meanings within waste diversion practice is shaped by the social and cultural structures of the tenant organisation and building workplace.

These meanings involve the understanding and significance assigned to waste reduction practices by employees, management, and other stakeholders. Efforts to promote sustainability culture can influence and transform these shared meanings, emphasising the importance of waste reduction and creating a sense of collective responsibility. Competency – as an element of waste diversion practice – refers to the

skills, knowledge, and abilities required to effectively implement waste reduction strategies. Sustainability initiatives have the potential to improve the competencies of individuals and teams in practicing environmental sustainability. At both the building and tenant organizational levels, citizens can develop the essential skills needed to participate in waste diversion and reduction practices. The third element, materiality, is associated with the physical aspects and infrastructure integral to waste diversion and reduction practices. This aspect may be linked to workplace structures, such as green office building features, as well as materials specific to certain tenant organizations.

## Meaning

The concept of social practice theory (SPT) emphasises the significance of the meaning element within a social practice (Haslanger, 2018; Shove et al., 2012), particularly in the context of waste diversion and reduction. This meaning is based on shared informational content and background assumptions, which individuals shared as carriers and performers of the practice. Cultural factors contribute to the formation and transformation of collective conventions, which can either hinder or facilitate actual waste diversion and reduction practices. As noted in the study's conceptual framework, the relocation of tenant organizations to the high-performance green office building (HPGOB) was viewed as an opportunity because the building's features fostered a sense of shared identity, values, symbols, and assumptions regarding sustainability practices both within individual organisations and across the building. Consequently, reshaping the meaning element of a practice can serve as an entry point for changing

specific practices (Revilla & Salet, 2018). In another study done under the same broad research umbrella as the current thesis study, Reimer-Watts et al. (2022) found that certain building features clearly functioned as symbolic sustainable features that created sustainability-related values. Tenants perceived positively the opportunity of being in HPGOB, which was important to support preceding sustainability engagements for developing a shared sustainable value (Reimer et al., 2021). In theory, the new material arrangements (HPGOB) at the workplace are expected to give new meaning to the practice of waste diversion and reduction (Figueiredo et al., 2021).

A key aspect to consider when examining the elements of meaning in waste diversion and reduction practices is the alignment of robust organizational strategies, including mission, vision, policy, and leadership, with sustainability integration. Tenant A and Tenant B may already possess shared meanings and norms aligned with sustainability within their respective organisations. Sustainability is manifested in the mission, vision, policies, and leadership activities of Tenant A and Tenant B compared to Tenant C (Reimer et al., 2021). For example, Tenant A's mission statement includes inspiring sustainability-oriented changes, leading in research, and accelerating cleaner energy innovations. Leadership within and beyond Tenant A demonstrated a strong commitment to sustainability. Taking a role on culture of sustainability engagements at the building level – such as designing and preparing a series of workshops, trainings, and tours. Such organizational aspects could reshape the shared meaning element of waste diversion and reduction practices (Reimer et al., 2021).

However, the current study did not track qualitative data on how and what influences the meaning element of specific waste diversion and reduction practices. Nonetheless, certain pieces of information – such as Tenant B's policies to go paperless, implement clean desk policies, and encourage the use of reusable mugs – contribute to a shared understanding of sustainability in waste diversion practices within Tenant B's workplace. In addition, it was observed that both Tenant A and Tenant B expressed a high level of interest and requested to know the results of their waste assessments, which the research investigator shared with them. This kind of communication acts as a feedback loop that facilitates the emergence of a strong sense of sustainability across tenants, potentially reshaping waste diversion and reduction patterns. Moreover, these tenant organizations can adeptly navigate and harmonize the potential conflicts that may surface during communication processes involving bottom-up, top-down, and inter-tenant interactions within the context of building environmental management (Geobey, 2022).

Organisational policy represents another aspect of socially shared meanings of environmental sustainability practice that can facilitate or impede the social practice of waste diversion and reduction. For example, as noted earlier, Tenant B goes paperless for its business activities, has a clean desk policy, and encourages the use of reusable mugs. Tenant A's kitchen uses reusable coffee cups instead of disposable ones, and Tenant A provides plant-based meals for official meetings. Such practices can reduce waste generation and foster a positive meaning for the social practice of waste diversion. However, Tenant C has a policy of providing meals for employees' lunches.

This provision of amenities contributes to a high generation of compost at Tenant C's workplace which could negatively impact waste diversion and reduction practices.

In summary, changing and reshaping the meaning element of waste diversion and reduction practices in a workplace is feasible – particularly when some tenants already have a sustainability-oriented culture – and moving to HPGOB provides an excellent opportunity and entry point for further shifting organisational values and identities toward sustainability (Fiol, 1991). Organizational policies and any preceding efforts in encompassing sustainability through various sustainability engagements could contribute to the establishment of more stable underlying values and shared meanings related to environmental sustainability practices, waste diversion and reduction practice.

## Material

The opportunity to move to an HPGOB can be considered as introducing a new material to the citizens of the HPGOB, which contributed to reshaping the pattern of social practice of waste diversion at both organisational and building scales. However, not all organisations showed a strong change in the practice of waste diversion. We argue that there could be a difference with respect to social and organisational structures that could facilitate or impede reshaping the dynamics of the social practice of waste diversion. Social and organisational structures are comparatively stable structures that contain material elements, and the continued existence of social practice depends on these materials (Haslanger, 2018; Shove et al., 2012). The signage and design aspects

of waste receptacles emerge as important material aspects of the social practice of waste diversion and reduction (Keegan & Breadsell, 2021). Anecdotal data (as shown in Appendix E) indicate differences in materiality and design aspects of the tenants' waste receptacles. For example, Tenant A has a well-designed waste receptacle and disposal signage. The receptacle has customised openings based on the type of waste stream (e.g., paper is a narrow slot) and color-coded signage. These elements contributed to the agency of materiality that directly influences the social practice of waste diversion and indirectly influences an over-time reduction of waste generation by providing meaningful aspects of sustainability to the social practice of waste disposal.

In summary, the transition to an HPGOB has introduced new materials that have reshaped waste diversion practices. Social and organisational structures – for example, the signage and design of waste receptacles – play crucial roles in influencing waste diversion practices. Tracing the materiality elements through qualitative data collection can provide insights into waste diversion practices and their integration with other work routines in a workplace.

## Competency

Applying the perspective of social practice theory, we contend that the evolution of waste diversion and reduction practices, both within the building and among tenants, has stemmed from a positive transformation in the specific competencies needed for executing these environmental sustainability practices over time. Altering and refining



the social practice of environmental sustainability in a workplace necessitates the cultivation of particular socially shared skills or competencies, as discussed by Dreyer et al. (2021) In the context of the social practice of waste diversion and reduction, competencies related to socially shared understandings and the correct coordination of skills are required to sort and reduce waste (Süßbauer & Schäfer, 2019). Some specific competencies might further include judging the level of contamination of the waste to be disposed of in the correct receptacle bin and skills related to minimising food, plastic, paper, and package waste.

When tenants moved to HPGOB, there could have been decisions made by citizens of HPGOB to engage in social practices of waste diversion and reduction. For example, when employees of Tenant A first dispose of their waste into a new receptacle with a well-designed lid opening and clearly labelled instructions, this act could nudge other employees (as a carrier of social practice) to immerse themselves in shared waste-sorting competencies. Doing so could, in turn, help others engage in waste diversion as a collective sustainability action in the workplace. In other words, skill, and know-how to perform a social practice of waste diversion could be complemented by the new materiality of an HPGOB and its specific building features as well as the material structure limited to individual tenant organisations, i.e., waste receptacles of tenant organisations in the thesis study.

In our study, we assert that skills related to the social practice of waste diversion in a workplace are cultivated through the daily routines of employees, such as waste sorting after meals, during social gatherings, and at meetings. Nevertheless, a more

comprehensive grasp of the impact of these skills within the social practice of waste diversion and reduction could have been enhanced by employing qualitative data collection methods to trace their development and influence.

## 6. Conclusion

In conclusion, this research has provided a comprehensive analysis of waste diversion and reduction practices within a workplace environment, shedding light on both positive trends and areas of differentiation across different organizational scales.

At the building scale, our findings reveal a promising positive shift in waste diversion practices over time. However, the same level of progress was not observed in waste reduction practices. Conversely, at the tenant organizational scale, Tenant A and Tenant B displayed noticeable improvements in both waste diversion and reduction practices, while only Tenant C did not exhibit a similar positive trajectory.

Furthermore, our study underscores the significance of the workplace as a catalyst for promoting sustainability beyond its confines. We have presented compelling evidence that positive changes in waste diversion practices at work can lead to a spillover effect, influencing employees to adopt similar practices in their homes. Nevertheless, it is essential to acknowledge that this spillover effect is not immediate, as overtime changes with waste diversion practices at home showed a delaying response compared to the workplace.

### 6.1. Implication for scholars

Scholars engaged in the study of environmental sustainability practices can glean significant implications and valuable insights from the present research.

1. Importance of scale: The research highlights the significance of considering different organizational scales (e.g., building scale, tenant organizational scale) when studying environmental sustainability practices. Scholars should recognize that sustainability practices may vary widely across these scales, and a one-size-fits-all approach may not be effective.
2. Temporal Analysis: The research emphasizes the need for scholars to conduct temporal analyses when assessing environmental sustainability practices. Trends over time can reveal critical insights, such as positive shifts in waste diversion practices and the lack of progress in waste reduction practices. Longitudinal studies can help scholars understand the dynamics of sustainability initiatives.
3. Social Practice Theory: The findings underscore the importance of employing social practice theory when exploring how environmental sustainability practices evolve over time. Scholars should investigate the social, cultural, and behavioural aspects that influence these practices within workplace environments and other social settings. Understanding how practices are embedded in daily routines and social norms is crucial.
4. Workplace as a Catalyst for Sustainability: The research emphasizes that the workplace can serve as a catalyst for promoting sustainability both within and

beyond its boundaries. Scholars should investigate the mechanisms by which sustainability practices in the workplace influence employees to adopt similar practices in their homes. This spillover effect is valuable but not immediate, suggesting a need for research into the timeframe and factors that facilitate or hinder this diffusion.

5. **Interdisciplinary Approaches:** Environmental sustainability research benefits from an interdisciplinary approach. Scholars from various fields, including environmental science, sociology, psychology, and management, should collaborate to gain a holistic understanding of the complex dynamics involved in sustainability practices within organizations.

6. **Long-Term Sustainability Impact:** Researchers should recognize that sustainability practices may not yield immediate results. It is important to assess the long-term impact of initiatives and track how behavior changes evolve over time.

In summary, this research highlights the nuanced nature of environmental sustainability practices within workplace environments and encourages scholars to adopt a multi-scalar, temporal, and socially informed approach when studying and promoting

sustainability initiatives. Additionally, it underscores the potential for workplaces to act as agents of change in broader sustainability transitions.

## 6.2. Implications for Practitioners

Practitioners can gain valuable insights and derive meaningful implications from this research. Here are some of the key takeaways for practitioners:

1. **Scale-Adapted Strategies:** Tailor sustainability strategies based on the specific organizational scale. Recognize that waste diversion and reduction practices may vary significantly between the building and tenant organizational scales. Develop customized approaches and initiatives that address the unique challenges and opportunities at each level.
2. **Promote Best Practices:** Share the success stories of tenants (e.g., Tenant A and Tenant B) that displayed noticeable improvements in both waste diversion and reduction practices. Encourage knowledge sharing and collaboration among tenants or departments to promote best practices and inspire positive change.
3. **Harness Workplace as a Sustainability Catalyst:** Recognize the workplace's role as a catalyst for promoting sustainability beyond its confines. Invest in workplace-based sustainability initiatives that can have a positive spillover effect on employees' practices at home.
4. **Long-Term Perspective:** Understand that the spillover effect of workplace sustainability initiatives may take time. Maintain a long-term perspective and continue to support and reinforce sustainable behaviors both in the workplace and at home.

In summary incorporate scale-specific strategies to enhance sustainability efforts, recognizing that waste diversion and reduction practices vary across organizational levels. Encourage the dissemination of successful sustainability models and foster collaboration among stakeholders to promote best practices. Leverage the workplace as a catalyst for sustainability both within and beyond its boundaries, understanding the time required for its positive influence to extend to employees' homes. Maintain a steadfast, long-term commitment to supporting and reinforcing sustainable behaviours in workplace and home environments.

### 6.3. Implications for future research

This research lays the foundation for future investigations in two significant ways. Firstly, it distinguishes itself by contributing to the limited body of research that examines workplace environmental sustainability through the lens of social practice theory, aligning with other noteworthy studies in this field (Hargreaves, 2011; King, 2019; Süßbauer & Schäfer, 2019). By framing workplace sustainability as a social practice, this study sheds light on the evolving nature of social practices related to waste diversion and reduction. It offers an explanatory framework for understanding how and why these social practices transform over time. The study employs a fundamental social practice framework, scrutinizing the influence of changes in social, cultural, and organizational structures on each element and their interconnectedness. These elements are regarded as agents distributed across various aspects of the workplace. Future research could delve into how specific agents exert more influence than others in shaping the social practice of workplace environmental sustainability.

Investigating agency dynamics within social practices can reveal pivotal factors that shape sustainable behaviours in the workplace.

Secondly, this study underscores that exploring a single social practice within workplace environmental sustainability may not suffice for drawing conclusions about the evolution of unsustainable practices over time. It underscores the importance of investigating the interrelationships between various social practices, such as shopping, transportation and waste diversion and reduction routines. Understanding how these practices interconnect and mutually influence one another can yield valuable insights into the overall environmental sustainability of the workplace. Future research should consider integrating qualitative data to trace the connections between diverse social practices within a workplace. This approach would provide a comprehensive understanding of how environmentally sustainable practices are intertwined and influenced by various social, cultural, and organizational factors.

Furthermore, future research should explore the influence of sustainability interventions, such as fostering a culture of sustainability within the workplace, on the social practice of environmental sustainability, with a specific focus on waste diversion and reduction practices. Researchers should strive to evaluate the effectiveness of these interventions in shaping the patterns of waste diversion and reduction practices.



#### 6.4. Limitations of the Research

Although this study examined the impact of over-time change on the social practice of waste diversion at the tenant organisation and building levels, several important limitations must be acknowledged. First, the study did not consider staff turnover, which could have influenced the observed changes. It is possible that staff turnover has taken place among the three tenants, but we have insufficient data to determine which tenants have higher turnover rates. We argue that newly hired staff members may face limitations in showcasing a higher level of waste diversion practices, as they were not initially exposed to the culture of sustainability intervention. Such changes usually require a gradual transition over time.

Second, the study was unable to explore the long-lasting effects waste diversion and reduction practices beyond the study period. The ongoing process of longitudinal data collection was disrupted by the pandemic, leading to the closure of the buildings for up to two years. Consequently, it was not possible to assess whether the changes in the social practice of waste diversion would be sustained over time. It is important to recognise that the findings of this study are therefore preliminary and may not fully capture the potential long-term effects.

Nevertheless, the study does suggest that achieving lasting and stable changes in the social practice of workplace environmental sustainability is feasible. This implies that the initial changes observed during the study could be built upon and further developed to establish a more sustainable waste diversion practice within the workplace.

To address these limitations, future research should consider incorporating staff turnover as a potential factor influencing the social practice of waste diversion. Long-term studies that extend beyond the disruptions caused by external factors such as the pandemic would provide a more comprehensive understanding of sustainability initiatives.

Overall, the thesis provides a comprehensive analysis of waste diversion and reduction practices in workplace environments, uncovering positive trends and disparities across different organizational levels. At the building scale, our findings indicate a promising improvement in waste diversion practices over time, although the same level of progress was not observed in waste reduction practices. In contrast, at the tenant organizational scale, only Tenant A and Tenant B demonstrated significant enhancements in both waste diversion and reduction practices, while Tenant C did not exhibit a similar positive trajectory. Furthermore, our research underscores the workplace's pivotal role as a catalyst for promoting sustainability within and beyond its confines. We present compelling evidence that positive changes in waste diversion practices at work can trigger a spillover effect, inspiring employees to adopt similar practices in their homes. It is important to note, however, that this spillover effect does not occur immediately, as changes in waste diversion practices at home show a delayed response compared to the workplace.

Scholars in the field of sustainability management can gain valuable insights from this research. It underscores the importance of considering different scales (e.g., building, tenant organisation etc.), conducting temporal analyses, applying social practice theory, and recognizing the workplace as a catalyst for sustainability. Collaboration among disciplines and assessing long-term impacts are also crucial in understanding and promoting sustainability practices within a workplace.

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## Appendix A: Ethical Clearance

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**Cc:** [Coulombe Simon\(Co-Investigator\)](#); [Dreyer Bianca\(Student\)](#); [Marcus Joel\(Co-Investigator\)](#); [Paul Parker](#); [Reimer-Watts Benjamin Kai\(Student\)](#); [Spadafore Brittany\(Student\)](#); [Whitney Stephanie\(Co-Investigator\)](#); [Zitars Jillian\(Student\)](#); [Karen Pieters](#); [reb@wlu.ca](mailto:reb@wlu.ca); [do-not-reply-laurier@researchservicesoffice.com](mailto:do-not-reply-laurier@researchservicesoffice.com)  
**Subject:** Joint Review Clearance Notification: REB #6072/ORE #40933  
**Date:** Friday, June 07, 2019 10:15:13 AM

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Wilfrid Laurier University

Office of Research Services

### Joint Notification with the University of Waterloo of Research Ethics Clearance

June 07, 2019

Dear Manuel,

Laurier REB # 6072  
UW ORE File # 40933  
Project, "JOINT UW - Evolv1 Research Study: Investigating human factors in green office buildings"  
REB Clearance Issued: June 07, 2018  
**Expiry / End Date: January 31, 2021**

The Wilfrid Laurier University Research Ethics Board and the University of Waterloo Research Ethics Committee have reviewed the above proposal and determined that the proposal is ethically sound. If the research plan and methods should change in a way that may bring into question the project's adherence to acceptable ethical norms, please submit a "Request for Ethics Clearance of a Revision or Modification" form for approval before the changes are put into place. This form can also be used to extend protocols past their expiry date, except in cases where the project is more than four years old. Those projects require a new REB application.

Please note that you are responsible for obtaining any further approvals that might be required to complete your project.

Laurier REB approval will automatically expire when one's employment ends at Laurier.

If any participants in your research project have a negative experience (either physical, psychological or emotional) you are required to submit an "Adverse Events Form" within 24 hours of the event.

All the best for the successful completion of your project.

(Useful links: [ROMEO Login Screen](#) ; [REB Students Webpage](#); [REB Connect Webpage](#))

Yours sincerely,

Karen Pieters, MPH

Jayne Kalmar, PhD

Manager, Research Ethics  
University of Waterloo

Chair, University Research Ethics Board  
Wilfrid Laurier University

Note 1: This project must be conducted in accordance with the description in the application for which ethics clearance has been granted. All subsequent modifications to the protocol must receive prior ethics clearance.

Note 2: Researchers must submit progress report for ongoing REB research projects annually. In addition, researchers must submit a study closure form at the conclusion of the project. These reports must be submitted to both institutions. ROMEO will automatically keep track of these annual reports for you. When you have a report due within 30 days (and/or an overdue report) it will be listed under the 'My Reminders' quick link on your ROMEO home screen; the number in brackets next to 'My Reminders' will tell you how many reports need to be submitted. Protocols with overdue annual reports will be marked as expired. Further the REB has been requested to notify Research Finance when an REB protocol, tied to a funding account has been marked as expired. In such cases Research Finance will immediately freeze funding tied to this account.

Note 3: Any events related to the procedures used that adversely affect participants must be reported immediately to the research ethics board/committees.

**Please do not reply directly to this e-mail. Please direct all replies to [reb@wlu.ca](mailto:reb@wlu.ca)**

**From:** [do-not-reply-laurier@researchservicesoffice.com](mailto:do-not-reply-laurier@researchservicesoffice.com)  
**To:** [Beimer Manuel\(Principal Investigator\)](#)  
**Cc:** [Spadafore Brittany\(Student\)](#); [Whitney Stephanie\(Co-Investigator\)](#); [Zbars Jillian\(Student\)](#); [Coulombe Simon\(Co-Investigator\)](#); [Dreyer Bianca\(Student\)](#); [Marcus Joel\(Co-Investigator\)](#); [Paul Parker](#); [Beimer-Watts Benjamin Kal\(Student\)](#); [Karen Pieters](#); [reb@wlu.ca](mailto:reb@wlu.ca); [do-not-reply-laurier@researchservicesoffice.com](mailto:do-not-reply-laurier@researchservicesoffice.com)  
**Subject:** Joint Review Clearance Notification: REB #6072/ORE #40933  
**Date:** Monday, June 10, 2019 3:45:53 PM

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**Wilfrid Laurier University**  
**Office of Research Services**

**Joint Notification with the University of Waterloo of Research Ethics Clearance**

June 07, 2019

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Laurier REB # 6072  
UW ORE File # 40933  
Project, "JOINT UW - Evolv1 Research Study: Investigating human factors in green office buildings"  
REB Clearance Issued: June 07, 2019  
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## Appendix B. Efforts in co-creating culture of sustainability

The tenants of the high-performance green office building (HPGOB) relocated to their new premises in 2018, marking an important milestone in the co-creation of a culture of sustainability (COS) within the building. The initial proposal for co-creating COS came from Tenant A, a clean tech innovation hub. Since then, continuous efforts have been made to inspire and encourage sustainable practices among all occupants of the building. To facilitate this co-creation process, a part-time manager of the culture of sustainability was appointed, dedicated to supporting and guiding the initiatives (Reimer et al., 2021).

One significant step taken toward establishing a culture of sustainability was the organisation of workshops. These workshops served as a platform for engaging with the building tenants, and they were well attended by managers, employees, and researchers. The workshops were open to all occupants of the building, providing a space for inspiration and collaboration (Reimer et al., 2021). By participating in these workshops, building citizens were empowered to self-organize into small groups and lead various sustainability initiatives within their organisations and the broader building community. The manager of culture of sustainability played a vital role in providing guidance and support to these citizen-led initiatives (Reimer et al., 2021).

The outcomes of these collective efforts were diverse and impactful. Citizens initiated sustainability workshops and formed community-building groups. Daily walks and active transportation were encouraged, highlighting the importance of physical activity, and reducing carbon emissions. The building itself featured sustainability signage, showcasing key green features through a public slideshow. In addition, lunch-and-learn sessions were held within tenant organisations to raise awareness and foster knowledge-sharing on sustainability-related topics (Reimer et al., 2021). These activities created a sense of involvement and ownership among the building's occupants.

Moreover, those interested in exploring the visible aspects of sustainability and culture within the building had the opportunity to participate in free tours. These tours allowed participants to witness firsthand the environmental features and practices that contributed to the building's net-positive energy status. By offering these experiences, the building management aimed to educate and engage occupants in sustainable practices (Reimer et al., 2021). Appendix 1 provides further details on the workshops and events that were organised to facilitate the co-creation of a culture of sustainability.



However, the momentum of the COS co-creation process was disrupted by the emergence of the COVID-19 pandemic, leading to the closure of the building for nearly two years. The pandemic brought about unprecedented challenges and forced a pause in the activities and initiatives aimed at building a culture of sustainability. The research conducted for this study considered the progress made in co-creating COS until the official announcement of the COVID-19 pandemic in the Waterloo Region, which occurred in March 2020.

In conclusion, the tenants of the HPGOB embarked on a journey to co-create a culture of sustainability within the building. Through workshops and initiatives facilitated by the Manager of culture of sustainability, the occupants were encouraged to embrace sustainable practices and take ownership of their impact on the environment. However, the progress of this co-creation process was interrupted by the COVID-19 pandemic. Nonetheless, the efforts made so far showcased the potential for building occupants to drive positive change and contribute to a sustainable workplace. The ongoing commitment to co-creating COS in the face of challenges exemplifies the resilience and determination of the building community to pursue a greener future.

## Appendix C: Workshops and events on co-creating culture of sustainability in HPGOB

The initial workshop in the series introduced the overall workshop series, explained its expected progression, and introduced the core team to the participants through presentations, which was an unusual approach. Throughout the series, participatory processes were the norm, with a heavy emphasis on world-café-style processes to facilitate conversations across different organisational boundaries. The design of the COS co-design workshops followed a broad framework based on the WISIR Social Innovation Lab model. It began with a system mapping workshop, was followed by a system redesign workshop, and concluded with a prototyping workshop. It's important to note that the Social Innovation Lab model is not a rigid set of instructions but rather a set of principles and overall guidance.

In addition to these workshops, two more were planned to evaluate previously launched prototypes and design new ones based on the knowledge gained. Initially, the plan was for each workshop to span an entire day, but due to time constraints, they were delivered over extended 90-minute lunch periods. Workshop 1 focused on system mapping to identify leverage points within and between the building and its tenants, while Workshop 2 prioritised the most promising leverage points for intervention. Workshop 3 involved developing prototypes, specifying timelines and activities, and assigning responsibilities to participants who would implement these prototypes. Three co-designed prototypes were created, and a fourth one was launched and led by a graduate student for their thesis research.

After a six-week gap for participants to launch their prototypes, Workshop 4 served as a collective debriefing session to evaluate the prototypes. One week later, Workshop 5 followed, focusing on another round of prototype development, like Workshop 3. It is worth noting that few of the prototypes placed significant emphasis on environmental sustainability. This suggests that, in the early stages of building a COS, participants prioritise the "culture" element of the COS over the "sustainability" element, which aligns

with the theory of change guiding the COS strategy. This preference was further evident during Workshop 5. However, the implementation of these prototypes faced initial setbacks as the COS manager left immediately after Workshop 5, and with limited support from tenants, most of the prototypes from this round were not implemented. In fact, it took more than 8 months for any of these prototypes to be implemented, by which time a new culture of sustainability management had been established in their role for almost half a year.

Main activities and events in the process of co-creating culture of sustainability in HPGOB

Main activities and events	Time happened
Culture of sustainability core team design workshop	June 2018
First building tenants move-in	September 2018
Original culture of sustainability manager hired	September 2018
Workshop 1 (system mapping)	Early February 2019
Workshop 2 (system design)	Mid-February 2019
Workshop 3 (experimentation 1)	Late February 2019
Workshop 4 (Evaluation)	Early May 2019
Workshop 5 (experimentation 2)	Late May 2019
Original culture of sustainability resigns	June 2019
New culture of sustainability hired	August 2019
Culture of sustainability team reflective debrief	August 2019
Covid 19 Shut down	March 2020

## Appendix D: Survey Questions

### I. Social and organizations related questions.

1. The last letter of your last name? If married, use the last letter of your maiden name.
2. The first letter of the city you were born in?
3. The first letter of the month in which you were born?
4. The last digit of the year you were born?
5. The last digit of the day on which you were born?
4. What organisation are you primarily affiliated with at evolv1?
  - i. Tenant A
  - ii. Tenant B
  - iii. Tenant C
  - iv. Other specify \_\_\_\_\_
5. What organization are you affiliated in Tenant A? \_\_\_\_\_

### II. Waste diversion related questions

1. Approximately what percentage of your wastepaper/cardboard goes to recycling at work? \_\_\_\_\_
2. Approximately what percentage of your wastepaper/cardboard goes to recycling at home? \_\_\_\_\_
3. Approximately what percentage of your plastic and glass containers go to recycling at work? \_\_\_\_\_
4. Approximately what percentage of your plastic and glass containers go to recycling at home? \_\_\_\_\_
5. Approximately what percentage of your food scraps and organic waste (e.g. banana peels) goes to compost/green bins at work? \_\_\_\_\_
6. Approximately what percentage of your food scraps and organic waste (e.g. banana peels) goes to compost/green bins at home? \_\_\_\_\_

## Appendix E: Tenant Waste Bin



Tenant A waste bins



Tenant B waste bins



Tenant C waste bin