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Abstract. Green Supply Chain Management (GSCM) is considered to be the most effective management tool that aims to integrate environmental sustainability thinking into the built environment. This is in relation to its ability to substantially reduce greenhouse emissions, energy consumption, pollution, and other drivers of negative environmental change in the built environment. Despite the implementation of GSCM practices, climate change continues to occur with a steady rise in greenhouse gas emissions per year that are associated with the built environment. Hence, there is a need for a proactive regenerative approach that focuses not only on reducing negative environmental footprints but also aims to create net positive impacts on the environment. This study aims to address this issue by first identifying the dominant forms of construction GSCM practices and their performance limitations through a Systematic Literature Review (SLR). The result revealed that regenerative factors were lacking in current GSCM practices. To further explore the nature of expanding current GSCM practices, a regenerative-based GSCM model was developed that demonstrates the relationship between regenerative and GSCM practices. This research addresses the gaps in current GSCM practices which could serve as a strategic response to climate change in terms of both mitigation and adaptation responses.

Keywords: Green Supply Chain Management (GSCM), construction, regenerative practices, sustainability, systematic literature review.

1. Introduction

Construction projects are becoming increasingly complex while the conventional methods of managing them have stayed the same over the years [1]. This could be a result of the complexity of designs, which requires inputs from different construction stakeholders such as the designers, suppliers, and contractors. This has led to fragmentation where suppliers and contractors specialise in a given project and are contracted to deliver only in their area of expertise [1]. Also, Bhool and Narwal [2] argued that construction activities involve large volumes of material resources, which demand a systematic process in regards to their selection, extraction, manufacturing, assembly, and delivery. The chronological and systematised form of these processes is known as a supply chain. Supply chain management (SCM) on the other hand, is the systemic coordination of business functions and strategies within a company and across businesses within the supply chain, to improve the performance of the company and the entire

supply chain [3]. The main objectives of SCM include reduced cost, improved end-to-end processes, communication, and interaction among supply chain partners, and also improved performance and productivity in a way that brings benefits to all supply chain participants [4].

However, increasing environmental pressures in recent years from communities and consumers have led to the development of stricter environmental regulations in many instances that require manufacturers to integrate environmental issues in their management activities [5, 6]. This trend has been particularly intensified with new European Union environmental policies and legislation such as treating Waste Electrical and Electronic Equipment (WEEE), Restriction of Hazardous Substances (RoHS), and Energy Using Products (EuP) [7]. This extensive responsibility, which improves the upstream and downstream dimensions of an organisation, is called green supply chain [8]. However, Green Supply Chain Management (GSCM) comprises the management of all activities related to minimising the environmental impact of all its supply chains which contribute to its final products to achieve zero net harm to the environment [9].

In the construction industry, GSCM consists of multiple steps of actions that start from the design stage through the end of the building life. This is integrated into the conventional supply chain network, taking into consideration environmental protection, economic benefits, and social improvement which eventually can minimise and eliminate the negative impacts of the supply chain on the environment [10]. Several studies, though not all, considered the objectives of GSCM. These were argued to be: increasing the competitive advantage of a firm [11], providing stakeholders with added value [9], and improving the performance of a supply chain ecologically, economically, and operationally [12].

Despite the numerous benefits of the implementation of GSCM in the construction industry, its guiding principles are typically only geared toward the design and construction of buildings that have a less negative impact on the environment. Consequently, Pagell and Wu [13] concluded that 'true sustainability is absent in GSCM. The authors argued that to be truly sustainable, a supply chain should be able to limit negative environmental impact, and have the potential of net environmental benefit as the ideal goal. For this reason, there is a need for the construction industry to shift from green to a regenerative paradigm that emphasises the importance of engaging with the living world, and of the co-creative partnership with nature based on strategies of adaptation, resilience, and regeneration [14].

This research, therefore, explores the dominant forms of GSCM practices in the construction industry and their limitations in terms of performance. To a large extent, it explores the need to integrate regenerative practices into GSCM and identify different forms of regenerative practices to shift the focus of construction activities from not only reducing negative environmental impacts across the supply chain but to revitalise the built environment.

The findings from this research will be the first to identify and integrate regenerative practices into each stage of GSCM, thus developing novel, "regenerative-based GSCM practices" for the construction industry. With this, the performance measurement of GSCM or the lifecycle assessment of construction projects will be based on not only limiting negative environmental impacts but also improving the built environment. In addition, this study will contribute immensely to the existing body of knowledge regarding GSCM in the construction industry and call for a rethink of the way we design, construct and manage the built environment throughout its lifecycle.

2. From Green to Regenerative Paradigm: A review

The 'green' construction movement has focused mainly on green buildings which aim to: reduce damage to sites; reduce the need for new infrastructure; reduce the impacts on natural features and site ecology during construction; reduce the potential environmental damage from emissions and outflows; reduce the contributions to global environmental damage; reduce resource use of energy, water, and materials; minimize the discomfort of building occupants; and minimize harmful substances and irritants within building interiors [15, 16]. Hence, if we do not make this fundamental transition towards regeneration, it will be impossible to go beyond simply slowing the rate of depletion and degradation [17]. To do so, Craft, et al. [18] proposed that we must engage with the living world by (re)aligning human and natural systems.

According to Pedersen Zari [19], the built environment should not only reduce its environmental footprint but should also create net positive environmental benefits. Hence, there is a need for a transition towards regenerative thinking. Regenerative thinking redefines the built environment – from the old, building-centric definition to one that includes the relationships between and among buildings, infrastructure, and natural systems, as well as the culture, economy, and politics of communities [17]. Du Plessis [14] described regenerative paradigm as emerging out of the transition from a 'mechanistic' to an 'ecological' or living systems worldview. According to the author, regenerative paradigm emphasises the importance of engaging with the living world, and of the co-creative partnership with nature based on strategies of adaptation, resilience, and regeneration.

To fully understand the benefits of shifting from a green to regenerative paradigm in the built environment, the following sub-sections encompass important regenerative practices that could be integrated across the construction project lifecycle.

2.1. Design Stage

Mang and Reed [17] define regenerative design as the "reconnection of human aspirations and activities with the evolution of natural systems. It covers all green and sustainable building criteria (e.g., the footprint of the material needs to be considered in the selection of material – reused, recycled and local materials can have priority) [20]. Regenerative design requires a shift from prescriptive metrics towards descriptive metrics, shifting away from a focus on rules and regulations that may lead to contextually inappropriate solutions; from a product-based focus towards a process-based focus; and from self-assertion thinking (rational, analytical, reductionist, and linear) towards integration thinking (intuitive, synthetic, holistic and non-linear) [15, 16, 21].

2.2. Procurement or Purchasing Stage

In specifying a building material, Peretti and Druhmann [22] explain two ways that specifications of construction materials can support communities, equity and reduce negative impacts upon them. According to the authors, the first method is specifying local materials that will engage a local workforce, utilise local skills and craftsmanship, and provide support for local employment. The second method is through specifying products from manufacturers whose ethics and governance ensure gender equality and responsible working conditions.

2.3. Transportation Stage

Statistics show that transportation alone is responsible for a seventh of greenhouse gas emissions [23]. As a result, the Intergovernmental Panel on Climate Change (IPCC) concludes that transport systems must seek to concurrently enhance mobility, and build resilience to climate change [24]. Furthermore, [25] opined that the built environment professionals must seek to design, construct, use, and operate transport infrastructure in a way that optimises operability and resilience in dynamic and unpredictable environments.

2.4. Construction Stage

Huang, et al. [26] revealed that technologies such as automation and robotics contribute to the development of mechanisms and processes for the transformation of the construction industry towards more regenerative solutions that can reduce energy consumption whilst at the same time can offer benefits to society including customised and lower-cost products. Furthermore, to enable a shift from green to regenerative construction, Peretti and Druhmann [22] opined that today's tools such as Building Information Modeling (BIM) and Life Cycle Assessment (LCA) procedures have the potential to provide information about the material specification, quantities of materials required for construction, and embedded energy of materials.

2.5. End-Of-Life Management Stage

Current green design tools focus primarily on the 'use' cycle, with virtually no emphasis placed on extraction/production, recycling or end-of-life replenishment considerations [27]. To achieve a well regenerated built environment with less resource consumption, Mesa, et al. [28] suggest that reusing, refurbishing, and remanufacturing is advantageous as it preserves the utility and value of building materials.

3. Research Methodology

This paper represents an important part of an ongoing Ph.D. study that aims to develop a decision support system for a regenerative-based GSCM in the construction industry. As a result, this study involves developing a preliminary conceptual model for integrated regenerative-based GSCM practices. To fully understand the concept of Green Supply Chain Management (GSCM) practices of the construction industry and the need to integrate regenerative principles, a systematic literature review was conducted.

The first step of the systematic literature review adopted for this study is to identify the keywords related to GSCM and their performance measurement. The search string was carried out by joining the terms contained in the research title. The synonyms of these terms were joined using an 'OR' operator. The 'AND' operator was used to find documents that contain both terms. Also, the asterisk symbol was used to broaden the search and find words that start with the same letters. Overall, a total of 6 key phrases were used. Scopus, google scholar, and Web of Science were used as the source of information because of their high-quality standard and broad coverage. To identify recent studies, the timeframe was chosen from 2011 and 2021.

Upon the completion of the search, a total of 52 papers were selected for the SLR. To avoid the risk of omitting any relevant publications, a snowball approach was adopted to further check the references of the selected 52 articles. As a result, additional 9 relevant peer-reviewed articles were identified and manually added to the pool. After completing the snowballing process, a total of 61 papers were identified and used for the SLR.

4. Findings and Discussions

GSCM practices and their performance have steadily gained momentum from only 16% of the papers being published up to 2011, interest increasing in 2012, and a more dramatic upturn in 2016 and 2017. Nonetheless, the growing recognition of the topic is evidenced by the wide range and multi-disciplinary nature of the publication outlets of the 61 papers in the dataset.

4.1. Green Supply Chain Management Practices

The adoption of GSCM practices in the construction industry offers a wide range of benefits. However, various GSCM practices have been introduced by numerous researchers in the literature. The classification of GSCM practices in the construction industry depends on the views taken by the researchers. Table 1 shows the dominant forms of GSCM practices used in the construction industry based on the SLR.

Table 1: GSCM practices used in the construction industry

Code	GSCM Practices	References
	Green Design	
GD1	Consideration of materials with high recycled content	Ali, et al. [29], Liu, et al. [30]
GD2	Integration of photovoltaic panels during design	Handayani, et al. [31]
GD3	Integrating energy-efficient HVAC systems during design	Ng, et al. [32], Zhang, et al. [33]

GD4	Provision for the use of prefabricated components	Ng, et al. [32], Zhang, et al. [33]
	Green Purchasing	
GP1	Choose suppliers according to their green initiatives	Ali, et al. [29], Hajikhani, et al. [34], Zhang [35]
GP2	Procure non-toxic materials	Ali, et al. [29]
GP3	Purchasing recycled materials	Shurrab, et al. [36]
GP4	Regularly audit suppliers' green initiatives	Ali, et al. [29], Balasubramanian and Shukla [37]
	Green Transportation	
GT1	Adopt environment-friendly transportation channels	Ali, et al. [29], Tachizawa, et al. [38]
GT2	Utilize eco-friendly transportation systems	Ali, et al. [29], Ng, et al. [32], Benny and Joy [39]
GT3	Provision of accommodation near the project site	Balasubramanian and Shukla [37], TemaNord [40]
	Green Construction	
GC1	Comprehensive waste management plan on site.	Benny and Joy [39], Shrestha [41]
GC2	The use of fuel-efficient machinery	Shi, et al. [42]
GC3	Utilizing energy-efficient and low hazardous materials	Shrestha [41]
	End-Of-Life Management/Reverse logistics	
RL1	Recover scrap from projects at the end of their lifecycle	Ali, et al. [29], Benny and Joy [39], Chileshe, et al. [43]
RL2	Energy-efficient execution of demolition activities	Ng, et al. [32]
RL3	Reusing waste building materials	Ali, et al. [29], Das [44]

4.2. Performance measurement of GSCM Practices

Environmental performance is regarded as the primary objective of GSCM. However, previous studies have been able to examine how GSCM can also provide economic and social sustainability benefits. Hence, it can be inferred that the performance measurement or benefits of GSCM are limited to three pillars of sustainability (environment, economic and social). An overview of the performance measures or limitations of GSCM practices is described in Table 2.

Table 2: Performance measurement criteria of GSCM practices

		Performance Measures/Limitations		
S/N	GSCM Practices	Environmental	Economic	Social
1	Green Design	[3,4]	[3,4]	[3,4]
2	Green Purchasing	[2,4]	[1]	[1,4]
3	Green Transportation/Logistics	[4]	[6]	[4]
4	Green Construction	[4,5]	[4]	[4]
5	Reverse Logistics	[6]	[6]	[6]

References: **1.** Zailani, et al. [45]; **2.** Esfahbodi, et al. [46]; **3.** Laosirihongthong, et al. [47]; **4.** Le [48]; **5.** Noor, et al. [49]; **6.** Balasubramanian and Shukla [37]

4.3. Regenerative-Based GSCM Model

Owing to the benefits of moving beyond sustainability to a regenerative paradigm, the systematic literature review conducted has not empirically addressed how the benefits of GSCM practices used in the construction industry can move beyond "limiting negative environmental impacts". Regenerative practices identified from the initial literature review of this study represent a shift in the scope and responsibilities of the construction professionals to develop a built environment that does not only focus on limiting negative environmental impacts of the built environment but to ensure continuous improvement, bringing together human and natural systems. Figure 1 represents the conceptual model for the regenerative-based GSCM model.

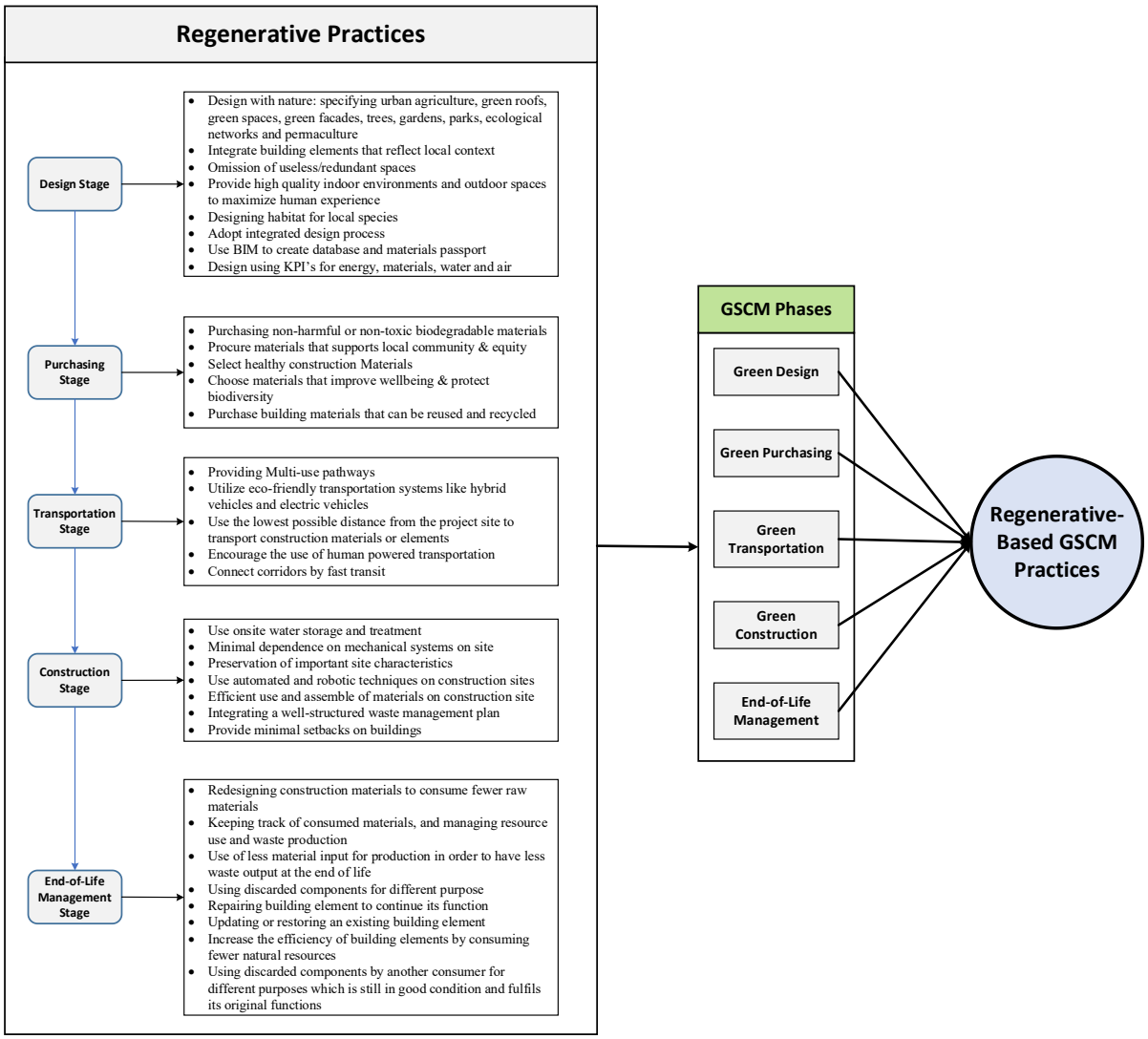

Figure 1: Conceptual Model for Regenerative-Based GSCM Practices

5. Conclusion and Further Research

The emerging themes and gaps highlighted in GSCM have shown that going 'green' is not enough to reduce negative environmental impacts and to provide a long-term solution to climate change. Hence, there is a need to integrate regenerative practices across the supply chain phases of the construction industry to enable the built environment to be adaptable to different conditions.

First, this study adopted a systematic literature review to identify the GSCM practices used in the construction industry and their limitations in terms of performance. The systematic literature review from the study shows that green design, green purchasing, green transportation, green construction, and end-of-life/reverse logistics are the dominant forms of GSCM practices used in the construction industry. Furthermore, the study revealed that the performance measurement or benefits of these GSCM practices are mainly centred around sustainability benefits, that is, seeking to only slow down the rate of depletion and degradation of activities within the built environment rather than providing net positive environmental benefits.

The preliminary literature review of this study helped identify core regenerative practices that could be integrated into each of the GSCM phases to enable a shift towards a regenerative paradigm which forms the basis of the conceptual regenerative-based GSCM model developed from this study.

The findings from this study would make significant contributions to improving the well-being of humans and the ecosystems as a co-evolutionary whole, while also acting as an alternative response to climate change. Future studies will focus on assessing and validating the developed regenerative-based GSCM model.

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