Green Supply Chain Management in the UAE Construction Industry

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Abstract: Supply chain management plays a significant role in the construction industry as it affects performance and effectiveness. The purpose of this study is to investigate how green supply chain management (GSCM) concepts and dimensions are being used in the construction industry in the United Arab Emirates (UAE). Based on a comprehensive literature review, the major concepts of GSCM considered for analysis are green initiation, green design, green construction, and green operation and maintenance. Survey data were collected from 91 respondents and analyzed using one-sample t-test, two-sample t-test, and Analysis of Variance (ANOVA) to test two hypotheses. Results revealed that all GSCM concepts and dimensions are generally applied with satisfactory levels in the UAE construction industry. There is no difference in respondents' perception regardless of respondents' experience or gender. The main contribution of this study is to use such a framework for GSCM and apply it in the UAE construction industry.

1. Introduction

The challenges and requirements needed to satisfy the new restricted environmental specifications in all industrial sectors forced the companies and business owners to green their business. These new ecological specifications need to integrate ecological requirements with supply chain management (SCM) practices. This integration is entitled Green Supply Chain Management (GSCM).

Many researchers tried to investigate and explore the effect of implementing GSCM on different industries sectors: For example, there are studies in electronic industries (Chien & Shih, 2007; Hsu & Hu, 2008; Kaur et al., 2018; Jermsittiparsert et al., 2019), food industries (Wang et al., 2013; Diab et al., 2015; Wang et al., 2016; Petljak et al., 2018), and other manufacturing industries (Zhu & Sarkis, 2004; Holt & Ghobadian, 2009; Shang et al., 2010; Huang et al., 2012; Vanalle & Santos, 2014; Mitra & Datta, 2014; Huang et al., 2015; Chin et al., 2015; Pang & Zhang, 2019; Rinaldi et al., 2021).

One of the most restricted and demanded environmental requirements areas is the construction sector due to the ecological impact of various materials and their impact on the environment regarding consuming energy, non-renewable resources, and generating waste and pollution (Abdelwahab& Othman, 2016). According to Balasubramanian (2014), construction contributes about thirty percent of global greenhouse gas (GHG) emissions.

Various researchers studied the construction industries from the GSCM perspective (Thipparat, 2011; Balasubramanian, 2012; Elbarkouky & Abdelazeem, 2013; Kim et al., 2016; Wibowo et al., 2018; Badi & Murtagh (2019); Ali et al., 2020). Few of them focused on studying the construction sector in UAE (Balasubramanian, 2012; Balasubramanian, 2014; Gharzeldeen & Beheiry, 2015; Balasubramanian & Shukla, 2017a; Balasubramanian, & Shukla, 2017b; El-Sayegh et al., 2019; Balasubramanian & Sundarakani, 2019; Hasan et al., 2020; El-Sayegh et al., 2021). Balasubramanian (2012) proposed a framework for measuring the barriers that block the implementation of GSCM in the construction industry in the UAE. He identified 32 barriers grouped into 12 criteria based on literature and expert opinion. Moreover, those criteria were classified as internal and external as well.

Balasubramanian (2014) developed a structural analysis of (GSCM) enablers in the construction industry in the UAE. He used the interpretive structural modeling (ISM) method to recognize the enablers' contextual relationships. The final model shows two different paths in the hierarchical model. Moreover, Balasubramanian & Shukla (2017a) tried to develop a comprehensive understanding of GSCM. The study used feedback and inputs from all key stakeholders, developers, architects, consultants, contractors, and suppliers, to improve the efficiency and effectiveness of greening in the construction sector. Furthermore, Balasubramanian & Shukla (2017b) proposed a framework that classified the drivers and the barriers into two parts: external and internal and the performance of the output into three categories: environmental, economic, and organizational performance. Their findings show a favorable influence on the three performance indicators: environmental, economic, and organizational. Moreover, drivers and barriers (external or internal) play an essential role in implementing green practices in the construction industry.

In Gharzeldeen & Beheiry (2015), a designed questionnaire was distributed to professional designers and contractors in various consulting and contracting firms in the UAE, to investigate the current usage of Green Design Parameters (GDPs). It was revealed that participants were aware of and used some green parameters. Also revealed from the data was that there is no correlation between using green parameters and the project objectives (cost and schedule).

Hasan et al. (2020) studied a lifecycle assessment methodology to measure environmental consequences. The authors studied a 3.5-km-long dual carriageway asphalt highway in Abu Dhabi during which they collected data over the following stages of the lifecycle: material extraction, production, transportation, construction, maintenance, and rehabilitation. Results confirm that earthworks estimate a significant part (26% of CO2eq.) of the environmental impacts for full roadwork.

In selecting contractors from a green perspective, El-Sayegh et al. (2019) identified twenty criteria grouped into five groups, namely firm characteristics, firm record, bid formats, environmental and socio-economic criteria. They used a literature review followed by a survey sent to professionals in UAE. The survey was designed to evaluate the selected criteria using a pair-wise comparison approach to enable the researchers to implement the Analytic Hierarchy Process (AHP). The results confirm that the five top criteria were: bid price, energy management, technical bid, proposed time, and water management.

El-Sayegh et al. (2021) tried to assess and evaluate the risk associated with the transition from traditional practices to green practices. They used a literature review followed by a survey distributed to professionals in the UAE. They identified thirty risks based on the literature review categorized into five groups: management, technical, green team, green materials, and economical. Five risks were rated from high to low as follows: lack of clients' funds, inadequate design information, design changes, tight schedule, and poor scope definition.

This research aims to develop a framework of the green supply chain process in the UAE's construction industry. The framework contains dimensions of GSCM concepts, which include green design, green initiation, green construction, green material management, and green operation and maintenance. Reverse logistics can also be found in the literature, but it was merged with Green Construction in this study. Green initiation is essential to assess whether a client requires green projects to save energy and provide healthy environments. It is the stage where the owner and consultant discuss the project lifecycle, as most clients are unaware of the severity of construction waste. Green design is one of the main stages of the project lifecycle, where decisions made in this stage may significantly impact the lifecycle environment of the project system. Its primary purpose is to design construction projects in environmentally friendly ways. It is essential to identify any possible effects on the project regarding environmental impacts during this stage. Green material management is the process of substituting hazardous materials or activities with more environmentally friendly materials or activities. Green construction aims to minimize resource consumption, waste, and emissions. Training, clearance, work application, and control are part of green operation and maintenance to maintain sustainable materials within a project.

As it can be seen from the literature in the UAE above, little was published about a general framework for the practices of GSCM in the UAE. Most of the studies concentrated on other gaps of research such as barriers for GSCM risks for transition to GSCM or concentrated on only one aspect such as design or contractor selection. Therefore the degree of applying the dimensions used in GSCM in the construction sector is investigated in this study.

2. Methodology

This study aims to evaluate the application of green supply chain management in the UAE construction industry. The data used in this study consists of questionnaire responses from the construction industry in the UAE. The questionnaire contains 2 sections related to GSCM in the UAE construction industry. While the first part of the questionnaire is used to collect personal information of the respondents, the second part handles the process of application and the interrelationships between the GSCM concepts and dimensions. Questions were answered using a five-point Likert-type scale (1 = not at all important, 5 = extremely important). The total number of responses is ninety-one, which is a reasonable number of respondents. To develop the framework of this research, an extensive literature review and an interview with an expert in the field were conducted. Data analysis was done using Microsoft Excel and R Software.

GSCM concepts and dimensions were studied through a comprehensive literature review and an interview with an expert in supply chain management from UAE. Consequently, five main GSCM concepts were identified with their dimensions as introduced in table 1. The interrelations between these main constructs in the framework are significant. Moreover, one dimension can affect more than one construct in the framework. For example, even though the use of environmentally friendly materials is considered part of Green Materials Management, it has to do with the Green Design. Another Green Construction example is the use of recycling, reusing, and remanufacturing processes, where sometimes it is found in the literature as Reverse Logistics. Moreover, educating customers, which is part of Green Operation and Maintenance, has also to do with the Green Initiation and Green Design constructs.

To study the relation between concepts and dimensions, a set of questions were generated from table 1. The first part of the questionnaire is used to collect personal information of the respondents such as gender and years of experience in the construction sector. Fourteen items in part 2 were based on several sources from the literature and expert input.

The framework of GSCM processes in the UAE construction industry was presented graphically in figure 1. Comparing table 1 and figure 1 reveals that to conserve resources and save energy and water (found in table 1 for Green Design), innovation is needed, as in figure 1. Another important thing to notice is that Reverse Logistics is combined with Green Construction.

Table 1: GSCM concepts and dimensions in UAE construction industry.

Concept	Dimension
Green Initiation	UAE construction industry is designing buildings with certain environmental considerations.
Green Design	UAE construction industry aims to conserve resources and manage waste during construction.
	UAE construction industry saves energy and water and reduces pollution during construction.

Green Materials Management	UAE construction industry encourages the use of environmentally friendly materials.
	UAE construction industry encourages making contracts with green suppliers and contractors.
	Construction industry in UAE tries to avoid improper storage space and methods that lead to material damage, and use materials from local suppliers.
	UAE construction industry uses green material handling equipment effectively through proper on site-transportation, control, and protection of materials during transportation.
	UAE construction industry selects certified green materials during construction.
	UAE construction industry follows government regulation and legislations that strives to obtain eco-labeling and environment certification.
Green Construction	Construction industry in UAE encourages green transportation to reduce harmful emissions produced.
	UAE construction industry considers human health and safety.
	UAE construction industry encourages recycling, reusing, and remanufacturing processes.
Green Operation and Maintenance	UAE construction industry focuses on green operations such as improvement of sewage and waste disposal facilities.
	UAE construction industry educates customers about green buildings.

Source: Author's findings based on literature review

3. Findings and Discussions

Table 2 provides descriptive statistics. All variables are sufficiently normally distributed. Skewness and kurtosis coefficients lie within the range of +2.00 and -2.00. A first look at the table shows that the levels of application of all the dimensions are more than 3.5 for except for the one about reducing harmful emissions in transportation, which is almost 3.4. From the 14 dimensions, 9 dimensions have average values higher than 4.0. Later, one sample *t*-test will be used for more insight. In regard of the gender of the respondents, 60% are males and 40% are females. About 40% of the respondents are young with experience of less or equal to 3 years as shown in figure 2.
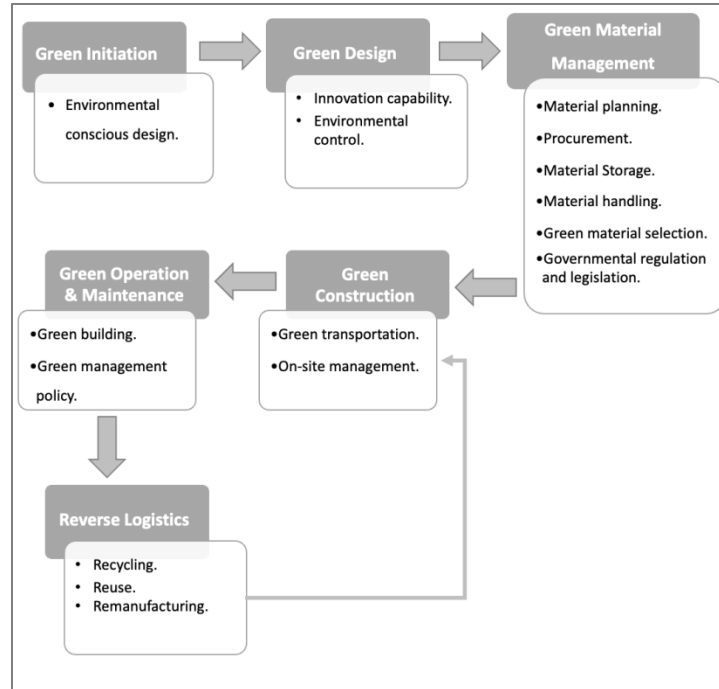
Figure 1: Framework of GSCM processes in the UAE construction industry.

Table 2: Descriptive statistics

Dimension	Min	Max	Mean	Std dev	Skewness	Kurtosis
UAE construction industry is designing buildings with certain environmental considerations.	2.000	5.000	4.077	0.842	-0.373	0.953
UAE construction industry aims to conserve resources and manage waste during construction.	1.000	5.000	4.022	0.914	-0.923	1.055
UAE construction industry saves energy and water and reduces pollution during construction.	1.000	5.000	3.835	0.997	-0.471	-0.255
UAE construction industry encourages the use of environmentally friendly materials.	2.000	5.000	4.033	0.907	-0.515	-0.718
UAE construction industry encourages making contracts with green suppliers and contractors.	1.000	5.000	3.868	1.040	-0.446	-0.778
Construction industry in UAE tries to avoid improper storage space and methods that lead to material damage, and use materials from local suppliers.	1.000	5.000	3.835	0.964	-0.334	-0.578

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UAE construction industry uses green material handling equipment effectively through proper on site-transportation, control, and protection of materials during transportation.	1.000	5.000	3.879	0.850	-0.420	0.156
UAE construction industry selects certified green materials during construction.	2.000	5.000	4.077	0.892	-0.720	-0.235
UAE construction industry follows government regulation and legislations that strives to obtain eco-labelling and environment certification.	1.000	5.000	4.033	0.919	-0.757	0.207
Construction industry in UAE encourages green transportation to reduce harmful emissions produced.	1.000	5.000	3.429	1.130	-0.307	-0.643
UAE construction industry considers human health and safety.	2.000	5.000	4.088	0.910	-0.533	-0.844
UAE construction industry encourages recycling, reusing, and remanufacturing processes.	1.000	5.000	4.033	0.977	-1.145	1.369
UAE construction industry focuses on green operations such as improvement of sewage and waste disposal facilities.	2.000	5.000	4.143	0.764	-0.552	-0.205
UAE construction industry educates customers about green buildings.	2.000	5.000	4.088	0.793	-0.429	-0.580

Source: Author's findings
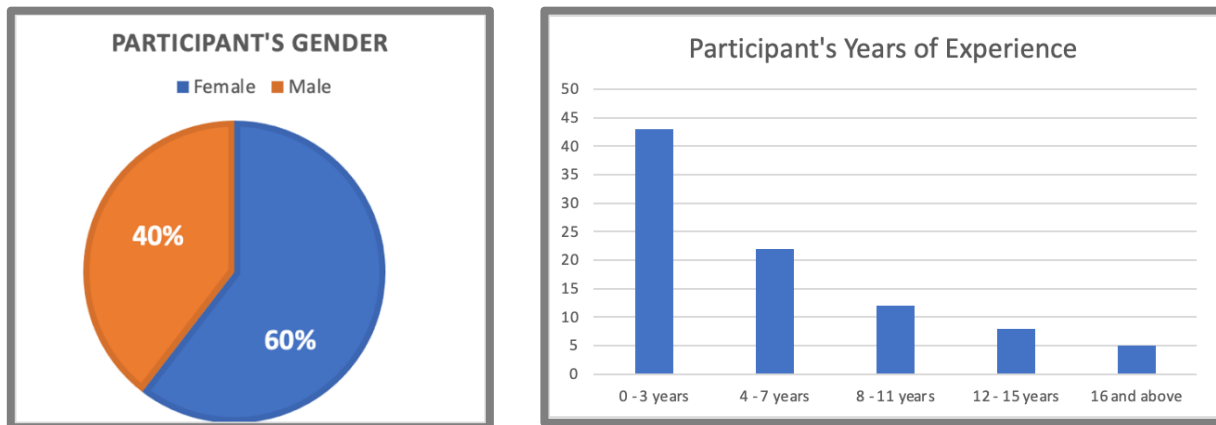
Figure 2: Questionnaire participants' analysis.

With Cronbach's alpha for green design, green materials and management, green construction, and green operation and maintenance of 0.84, 0.83, 0.81, and 0.76 respectively, the questionnaire data proves the reliability of the GSCM concepts and dimensions, as indicated in table 3. However, the "Green Initiation" concept has no value as it consists of one dimension only.

Table 3: Cronbach alpha values of GSCM concepts and dimensions.

Concept	*Cronbach Alpha*
Green Initiation	-
Green Design	0.8404
Green Materials Management	0.8277
Green Construction	0.8090
Green Operation and Maintenance	0.7602

Source: Author's findings

The framework in a structural way is shown in figure 3. The numbers on the arrows represent Cronbach alpha values reliability testing that shows the inter-relationship between each concept and its dimensions. Green initiation does not have Cronbach's alpha value because it includes only one dimension.

Based on the above findings and arguments, two hypotheseswere formulated:

H_1: Green practices of SCM are applied with satisfactory levels in the UAE construction industry.

H_2: Participants with different levels of experience in the UAE construction industry have different perceptions about the level of application of GSCM.
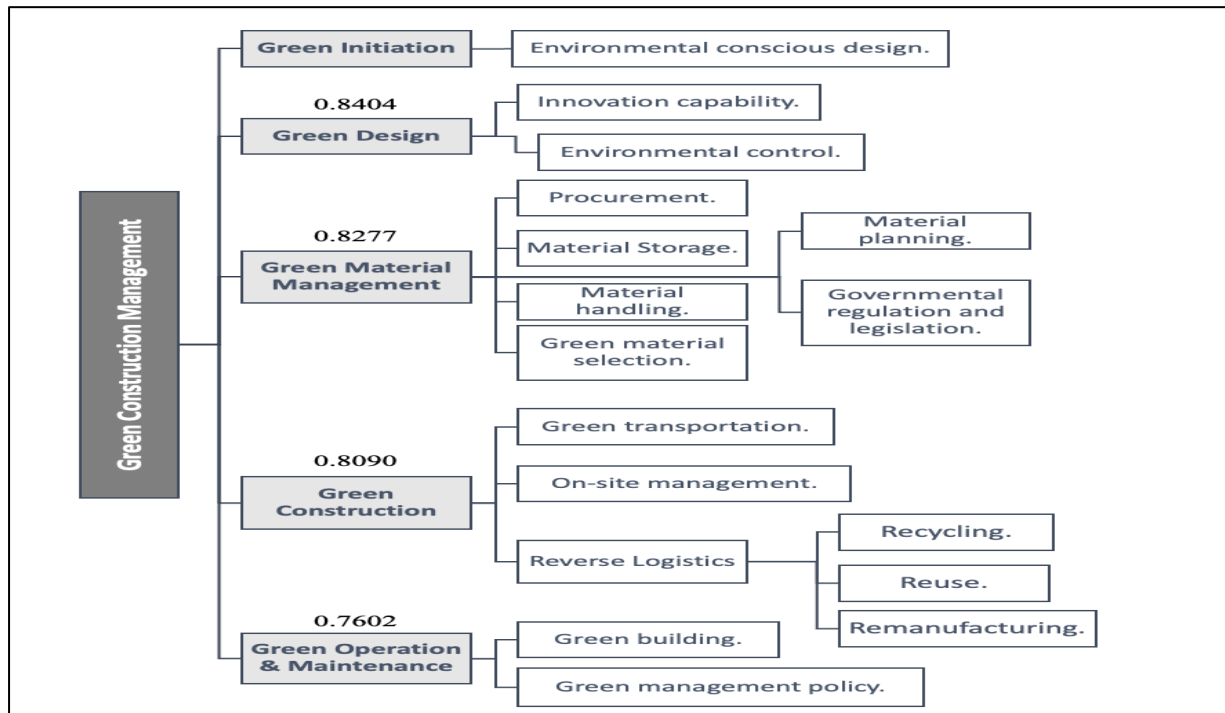

Figure 3: Framework for GSCM with Cronbach Alpha Values.

Hypothesis 1 was analyzed using one sample T-test. A satisfactory level was found chosen to be 3.5, which was found in some researches in the literature. Some studies use 3 instead of 3.5. P-value was calculated to check if the green practices of supply chain management are applied with a satisfactory level in the UAE construction industry. As can be seen from table 4, the p-values are extremely smaller than alpha value (0.05), therefore, the alternative hypothesis is accepted. This indicates that green practices of SCM are applied with high levels in the UAE construction industry. In principle, the results of the one-sample t-test can also be shown for each dimension of the 14 ones. The only dimension that was with a value larger than 0.05 is the one about reducing harmful emissions in transportation with a value of 0.72.

Table 4: One sample t-test analysis to test the first hypothesis.

Concept	P-value (of one sample t-test)
Green Initiation	2.1536E-09
Green Design	7.5061E-06
Green Material Management	4.96345E-09
Green Construction	0.00016
Green Operation & Maintenance	3.95084E-13

Source: Author's findings

To check the effect of gender on the perception of respondents regarding the 14 dimensions, a two-sample t-test was used. Results in table 5 show that there is no significant differences between males and females where the p-values are more than 0.05

Table 5: Two-sample t-test to check the effect of gender on the perception regarding the application of GSCM

Construct	Dimension Number	p-value
Green Initiation	1	0.65
Green Design	2	0.53
	3	0.85
Green Material Management	4	0.52
	5	0.96
	6	0.99
	7	0.38
	8	0.60
	9	0.86
Green Construction	10	0.23
	11	0.97
	12	0.97
Green Operation & Maintenance	13	0.30
	14	0.97

Source: Author's findings

Hypothesis 2 was examined using ANOVA test. The questionnaire was distributed to participants of five different levels of experience. Table 6 shows the results for the dimension about designing buildings using environmentally friendly materials. As can be seen, the p-value equals 0.274, which is greater than the alpha value (0.05). As a result, the null hypothesis is not rejected, meaning that regardless of years of experience, participants are encouraged to use environmentally friendly materials in designing buildings, which is a good indication for UAE construction industry.

Table 6: Single-factor ANOVA analysis for the dimension about using environmentally friendly materials.

SUMMARY

Groups	Count	Sum	Average	Variance
0-3 Years	43	166	3.860	0.932
4-7 years	22	90	4.091	0.658
8-11 years	12	49	4.083	1.174
12-15 years	6	25	4.167	0.167
16 years and above	8	37	4.625	0.554

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.3	4	1.074	1.308	0.274	2.478
Within Groups	70.6	86	0.821			

The same previous analysis can be done for all the fourteen dimensions as shown in table 7. It is clear through the p-values, that are greater than 0.05, that the experience does not affect the perception of the respondents about the level of applications of GSCM. This is except for the third dimension about saving energy and water and reducing pollution, which has a value of about 0.05 (exactly 0.049). Previously, it was found using a two-sample t-test that gender also does not affect the perception. These two tests confirm the main results about the level of applications of GSCM.

Table 7: Single factor ANOVA analysis for all the dimensions of GSCM

Construct	Dimension Number	p-value
Green Initiation	1	0.28
Green Design	2	0.16
	3	0.05
Green Material Management	4	0.27
	5	0.53
	6	0.16
	7	0.18
	8	0.49
	9	0.84
Green Construction	10	0.38
	11	0.22

	12	0.88
	13	0.18
Green Operation & Maintenance	14	0.20

4. Conclusion

The construction industry is known for its huge effect on the environment in terms of consuming energy, non-renewable resources, and generating waste and pollution. Supply chain management plays a main role in the construction industry as it provides effective management and improves performance. Implementing sustainability in the process of supply chain in the construction industry is an effective idea as it can help to protect the environment, enhance productivity, improve building quality, etc. The GSCM concepts and dimensions can be utilized in the construction industry to overcome the problems of inefficiency, waste production, and energy consumption. Therefore, this paper aims to investigate the level of application of GSCM concepts and dimensions in the UAE construction industry. Five main GSCM concepts were identified from a comprehensive literature review. Consequently, GSCM concepts and dimensions were examined and prioritized based on discussion with an expert to develop a framework for the UAE construction industry. In addition, data was collected from a questionnaire distributed to participants related to the UAE construction industry. Results revealed that all GSCM concepts and dimensions have a strong relationship in the UAE construction industry. Moreover, regardless of the respondents' years of experience in the construction industry, environmentally friendly materials are used at a satisfactory level, which shows a good indication for the UAE construction industry. The same result was found for almost all 14 dimensions.

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