Green Supply Chain Management: The Case of the Construction Sector in the United Arab Emirates (UAE)

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Complete List of Authors:	Balasubramanian, Sreejith; Middlesex University, Business; Middlesex University Dubai, Business Shukla, Vinaya; Middlesex University, Business
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Abstract

Restraining the negative environmental impacts of the construction sector constitutes one of the major challenges of the twenty-first century. However, efforts to address it have been largely fragmented. With environmental consequences of a construction project typically dispersed across its life cycle, i.e. from design through to end-of-life, greening this sector requires a supply chain wide focus inclusive of all key stages and stakeholders; also, all relevant aspects such as the nature of green practices implemented and associated drivers, barriers and performance implications need to be considered. This forms the focus of the present study where a comprehensive, green supply chain management (GSCM) oriented understanding of the construction sector is developed through the context of the UAE construction sector, and incorporating inputs from all key stakeholders, i.e. Developers, Architects/Consultants, Contractors and (material) Suppliers. The study contributes to improving the efficiency and effectiveness of greening of the construction sector.

Keywords: Green supply chain management, Construction, United Arab Emirates

1. Introduction

Environmental pollution and climate change have turned out to be one of the greatest challenges of the 21st century, which have forced governments and businesses alike to assess the environmental impacts of their activities (IPCC, 2007). The challenge is particularly acute for the construction sector given its outsized environmental footprint; it accounts for roughly one-third of the global carbon emissions, one-third of global resource consumption, 40% of the world's energy consumption, 40% of the global waste generation, and 25% of the world's water consumption (UNEP-SBCI, 2016). With growing urbanization (approximately 70% of the world's population is expected to live in urban areas by 2050 (UN-DESA, 2014)) and consequent increase in construction activities, the environmental consequences can be expected to be even greater in the future. The need to green the construction sector has therefore become critically important.

Green supply chain management (GSCM) or incorporating environmental concerns into supply chain management has emerged as a holistic environmental management approach (Malviya and Kant, 2015); with environmental impacts of a product/project typically occurring at all its lifecycle stages, a supply-chain-wide focus makes sense (Hervani et al., 2005; Wu et al., 2011). GSCM emphasises efficient, effective and extensive implementation of green practices, or activities/initiatives to reduce the environmental footprint (Awaysheh and Klassen, 2010; Perotti et al., 2012), which in turn depends on the ability to manage 'antecedents,' i.e. drivers and barriers that affect the implementation of green practices (Walker et al., 2012; Drohomeretski et al., 2014; Luthra et al., 2015) and 'consequences', i.e. the impact that green practices have on environmental and short and long-term financial performance (Rao and Holt, 2005; Green et al., 2012). Importantly, this understanding of green practices and associated 'antecedents' and 'consequences' has to be at the level of individual stakeholders (in a

sector) so that their conflicting interests can be managed and a unified, sector-wide greening is possible (Hervani et al., 2005; Gold et al., 2010; Drohomeretski et al., 2014). Such a comprehensive (GSCM oriented) investigation and resulting understanding could be used to green the construction sector. This forms the focus of the present work where a comprehensive investigation on construction covering green practices' implementation across all key stages (from initial development of the design to end of life demolition and recycling), drivers for and barriers to their implementation and their different performance implications, all at the level of individual stakeholders, i.e. Developers, Architects/Consultants, Contractors/Sub-Contractors and material Suppliers, is undertaken. Such an investigation has not been previously attempted which has been largely fragmented and disjointed: only specific green practices such as green purchasing (Varnas et al., 2009), antecedents for specific green practices such as drivers for green construction (Qi et al., 2010) and barriers to green purchasing (Sourani and Sohail, 2010), specific consequences such as environmental performance (Tam et al., 2006) and specific stakeholders such as Developers (Abidin, 2010) or Contractors (Qi et al., 2010) are considered in previous studies.

While the above comprehensive investigation could be based anywhere, choosing a setting where the construction intensity is high and green practices implementation has shown maturity can be expected to be more practically relevant. The United Arab Emirates (UAE) has been experiencing an unprecedented construction boom growing at more than 9% per annum in the last few years (Zawya, 2014; 2015); some of the largest construction projects in the world including the tallest structure (Burj Khalifa), the tallest hotel (JW Marriott Marquis), and the largest mall (Dubai Mall) have come up there recently. While this has been a cause of significant environmental degradation (around 75% of all the solid waste generated in UAE is from construction (SCAD, 2013)), including of carbon emissions, it has also triggered significant green practice implementation and propelled UAE to eighth in the world in terms of stock of LEED (or Leadership in Energy and Environmental Design) certified buildings (LEED, 2015) as well as managed to reduce its per capita carbon footprint (in metric tons) from 23 in 2008 to 20.4 in 2011, though UAE continues to be one of the highest per capita carbon emission countries (World Bank Country Report, 2016). UAE is therefore an appropriate context to conduct the investigation.

The rest of the paper is structured as follows. In the next section, previous GSCM work on construction is reviewed, the gaps identified and the associated research questions proposed. In the third section, the research methodology is explained and its appropriateness justified. Findings of the study are presented in section 4, while in section 5, which is also the concluding section, its research and practical implications along with limitations and suggestions for further work are discussed.

2. Review of previous GSCM work on construction

Though work on GSCM has been done in various other sectors such as manufacturing, automobile, electrical and electronics (Zhu et al., 2007; 2008; Luthra et al., 2015; Tseng et al., 2014), the construction sector is unique in several respects. Figure 1 represents the construction supply chain in

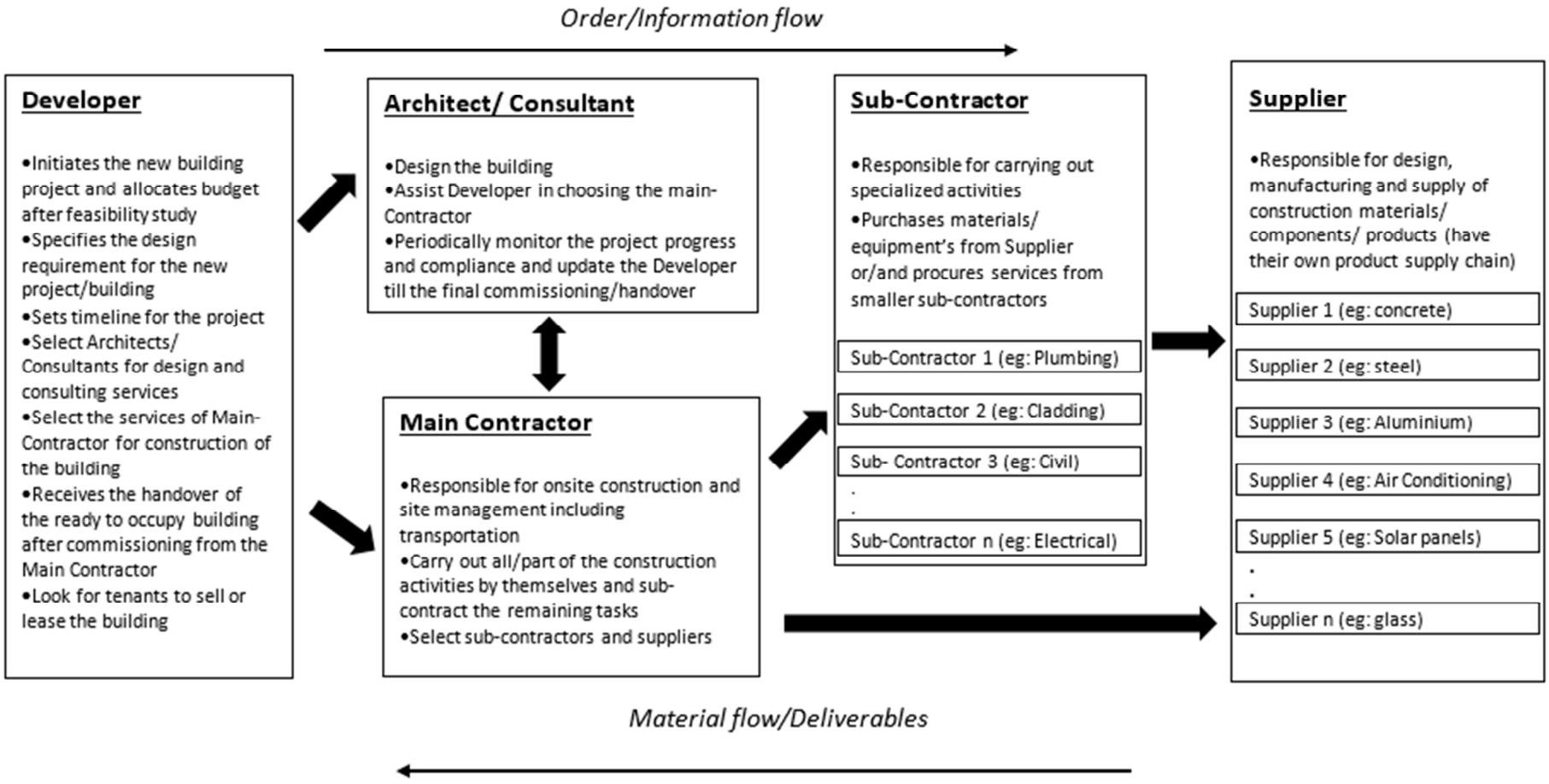

Figure 1. Construction Supply Chain

terms of its key stakeholders, their roles and responsibilities and the order/information and material/deliverable flow that take place. In contrast to the unilateral, long-term nature of the relationship between manufacturers and suppliers in typical manufacturing supply chains, construction supply chains are complex, diverse and fragmented and involve a multitude of stakeholders in dyadic, short-term/temporary relationships that last only until project completion (Rezgui and Miles, 2009); in a large construction project for example, the number of organizations involved could be in hundreds, if not thousands. This means that for the greening of the construction supply chain to be effective and extensive, each stakeholder needs to implement green practices to the best of their abilities in a coherent manner vis-à-vis others as any laggardness may adversely affect the overall greening efforts (Compact, 2010). Moreover, the construction supply chain has a reputation for low trust and adversarial relationships between stakeholders (Korczynski, 1996; Akintoye et al., 2000); for instance, Latham (1994) highlighted the adversarial attitude between the main Contractors and their Suppliers in the case of the UK construction sector. Therefore, understanding and addressing the conflicting interests of each stakeholder potentially could improve their active participation in the greening efforts. The one-off nature of construction contracts and lack of long-term relationships between stakeholders (Dubois and Gadde 2000; Briscoe et al., 2001) could also be affecting the greening of the construction sector.

Table 1 provides a summary of previous GSCM-related work on construction. Reviewing the work on green practices first, it would be useful to look at the core green practices (or practices associated with greening of the different functional stages including product design, material selection and sourcing, manufacturing, material and final product delivery and product disposal at the end of its life (Hervani et al., 2005; Srivastava, 2007)) separately from the facilitating ones (or practices undertaken at an intra-firm level to build resources and capabilities in order to achieve environmental goals and which include implementation of environmental management systems (EMS's) and ISO 14001 certification, formation of cross-functional teams to enhance cooperation and communication between departments for environmental improvements, conducting environmental auditing and environmental training programs (Seuring and Muller, 2008; Zhu et al., 2012)).

Looking at the previous work on core green practices, it is apparent from Table 1 that only a few studies have investigated green design practices (which involve integrating environmental consideration during design stage), and that too have not considered stakeholders' perspectives; the nature/details of these practices for individual stakeholders, i.e. Developers, Architects/Consultants, Contractors and (material) Suppliers is therefore unclear. The same is true for green purchasing practices (which involve integration of environmental considerations into purchasing policies, programs, and actions) as well; previous studies have either ignored stakeholders' perspectives completely (Ofori, 2000) or considered only specific ones such as Developers (Varnas et al., 2009) in their investigations. Studies on green construction practices or practices aimed at minimizing the adverse environmental impact during the physical construction phase have also been narrowly scoped with only specific practices such as pre-fabrication being studied (Jaillon et al., 2009). End of life green practices (which are practices aimed at

Table 1. Summary of GSCM-related studies in the construction sector

Study	Country	Methodology	Primary Focus	Stakeholders; their Characteristics*	Key Findings
Ofori (2000)	Singapore	Literature review	Greening of the supply chain	-	**Green purchasing practices:** Purchase of recyclable products and those with non-toxic ingredients, supplier training on environmental practices, supplier implementation of environmental management systems incl. ISO 14000 and supplier environmental audit
Ofori et al. (2000) Ofori et al. (2002)	Singapore	Survey	Environmental Management system (EMS) and ISO 14001	Developer, Consultant and Contractor	**Drivers of EMS and ISO 14001:** Mandatory government environmental requirements, client demands, end-purchasers demand for environmental-friendly buildings, pressure of competitors who have implemented similar systems, non-government environmental group campaigns, reducing material wastage, enhancing company's public image, reducing costs and environment protection **Barriers to EMS and ISO 14001:** High implementation cost, recovery of related investments, lack of government support, lack of knowledge, shortage of qualified personnel
Shen and Tam (2002)	Hong Kong	Survey	Environmental Management system (EMS)	Contractor	**Drivers of EMS:** Reduction in environment related fines and associated savings, improvement in corporate image, environment protection **Barriers to EMS:** Lack of government enforcement, increase in costs, lack of trained staff and expertise
Tam et al. (2006)	Hong Kong	Survey and interviews	Environmental performance	Developer, Consultant, Main/Sub-contractor; Large, Medium and Small firms	**Environmental performance measures:** Reduction in energy, material and water consumption
Adetunji et al. (2008)	UK	Case study	Sustainability in supply chains	-	**Drivers of sustainable practices:** Government regulations and associated fines, client requirements, top management commitment, reduction in total project costs, improvement in reputation and image, organizational vision on sustainability **Barriers to sustainable practices:** High implementation cost **Sustainable practices:** Implementation of EMS and ISO 14001, setting environment related pre-qualification criteria for suppliers, environmental training for in-house staff and suppliers, purchasing/using materials that cause less environmental damage and have higher recycled content **Environmental benefits:** Reduction in polluting emissions, environmental accidents and energy consumption, waste minimization, water conservation **Economic benefits:** Lower project costs
Jaillon et al. (2009)	Hong Kong	Survey	Pre-fabrication	-	**Barriers to pre-fabrication:** Higher cost per unit floor area in comparison to traditional approaches, lack of skilled labour **Environmental benefits:** Reduction in construction waste **Economic benefits:** Reduction in construction time and onsite labour requirement
Pitt et al. (2009)	UK	Survey	Sustainable practices	Developer, Architect, Contractor	**Drivers of sustainable practices:** Client demand, government regulations, financial benefits **Barriers to sustainable practices:** Lack of affordability, lack of awareness
Robin and Poon (2009)	Hong Kong	Survey	Cultural Shift in Sustainability	Developer, Architect/Consultant, Contractor and Supplier	Cultural shift in sustainability in terms of awareness, concern, motivation and implementation
Varnas et al. (2009)	Sweden	Survey and interviews	Green Purchasing	Developer	**Green purchasing practices:** Environmental criteria at the design stage, requirement to have an environmental and waste disposal plan, to use energy efficient onsite machinery and to use less environmentally harmful materials

*Blanks mean that specific Stakeholder/s and their characteristics are not considered in those studies

Table 1. (continued)

Study	Country	Methodology	Primary Focus	Stakeholders; their Characteristics*	Key Findings
Gangolells et al. (2009)	Spain	Focus group and case study	Environmental impact measures	-	**Environmental impact measures:** Greenhouse gas emissions, water consumption, waste reduction, material consumption, energy consumption, environmental accidents
Chen et al. (2010)	US	Survey	Sustainability measures	Developer, Architect, Contractor, Supplier	**Environmental performance measures:** Reduction in air emissions, material consumption, energy consumption and water consumption, reduction in waste generated. **Economic performance measures**: Reduction in material and waste disposal costs
Abidin (2010)	Malaysia	Survey	Awareness about sustainable construction	Developer; Small, Medium and Large firms	Environmental aspects of sustainability: High awareness Economic aspects of sustainability: Low awareness
Fernández-Sánchez and Rodríguez-López (2010)	Spain	Literature review and case study	Sustainability indicators	-	**Environmental Indicators:** Water consumption, air emission, material consumption, energy consumption and waste management **Economic Indicators**: Reduction in cost
Qi et al. (2010)	China	Survey	Drivers of green practices	Contactor; Small, Medium and Large firms	**Drivers of green practices:** Government environmental regulations, top management commitment, client pressure, pressure from environmental non-government organizations
Sourani and Sohail (2011)	UK	Interviews	Barriers to green purchasing	-	**Barriers to green purchasing:** Lack of funding and high capital cost, lack of awareness and knowledge, lack of long term partnership and lack of government incentives
Zhang et al. (2011)	China	Survey	Barriers to green practices	-	**Barriers to green practices:** Higher costs of implementation, lack of knowledge and awareness, lack of clarity in tender specification and conflict of stakeholder interests
Liu et al. (2012)	China	Survey	Drives and barriers to green practices	-	**Drivers of green practices**: Support/incentives from government and to gain reputation **Barriers to green practices**: Lack of green building professionals, high cost of implementation and lack of green construction knowledge **Green design practices:** Selection of sustainable sites, consideration in design to reduce material usage, use more environmental friendly materials and have more natural luminance and ventilation as well as provision for water reduction and recycling
Ng et al. (2012)	Generic	Literature review	Carbon dioxide reduction strategies across the lifecycle of a Building	-	**Carbon reduction in planning and design:** Natural ventilation, natural lighting, renewable energy integration, low energy lighting and low energy cooling and heating systems **Carbon reduction during material selection and construction:** Selection of materials with low embodied energy and high re-cycled content, use of fuel efficient machinery (onsite) and prefabricated materials (offsite) **Carbon reduction during end of life demolition:** Recycling and reuse of material
Carris et al. (2012)	UK	Case study	Sustainability in supply chain	-	**Drivers of sustainable supply chain:** Enhancing reputation, client requirements, regulation/legislation, corporate sustainability objectives, cost reduction **Barriers to sustainable supply chain:** Lack of awareness and knowledge, high cost of research and development for implementing sustainable practices
Akadiri and Fadiya (2013)	UK	Survey	Drivers of environmental practices	Small, Medium and Large firms	**Drivers of environmental practices:** Government regulation, pressure from clients, pressure from environmental non-government organizations, top management commitment towards environment and improving company image
Shi et al. (2013)	China	Survey	Barriers to green construction	Developer, Consultant and Contractor	**Barriers to green construction**: Additional costs for green construction, lack of awareness and knowledge and lack of green suppliers
Zutshi and Creed (2014)	Generic	Literature review	Environmental Management System (EMS)	-	**Barriers to EMS**: High cost of implementation, lack of stakeholder co-operation, lack of trained staff and expertise, long registration process for ISO 14001 certification **Economic benefits**: Lower material and energy costs and reduction in environment related fines

*Blanks mean that specific Stakeholder/s and their characteristics are not considered in those studies

ensuring energy-efficient demolition of buildings at the end of their lives and maximizing recovery and recyclability of materials) too are minimally discussed in the literature despite being known to significantly reduce the environmental burden; as per Blengini (2009) they can reduce the total life-cycle energy of a building by around 30%, and GHG emissions by approximately 18%. Finally, certain core green practices appear to be missing in the previous work. For example, no study reviewed appears to have looked at green transportation practices (or practices undertaken to reduce the environmental impact of transportation activities in construction projects). This despite transportation of materials/supplies accounting for roughly 6-8% of the carbon emissions in construction projects (Ng et al., 2012). Other relevant core green practices could have been missed as well.

Getting a detailed understanding of each relevant core green practice (both known and to be known), and for each stakeholder individually, is important. This is because altogether, they determine the life-cycle environmental impact of a construction project (and when aggregated, for the construction sector as a whole). It also makes sense to look at these practices together/holistically as there are interactions between them; for example, green design consideration in terms of building materials/components to be used could have implications for green purchasing, green construction and end of life green practices, and which therefore, require being studied together.

Next, we review previous work on facilitating green practices for construction, and here again, gaps in knowledge are evident. Table 1 reveals previous studies to have focused mainly on specific practices such as environmental management systems and ISO 14001 certification (Ofori 2000; Shen and Tam 2002; Zutshi and Creed, 2014); others such as environmental training and environmental auditing have seen limited work. Still others such as cross-functional integration (or coordination across different functions and departments) known to facilitate the realization of green goals in other sectors (Zhu et al., 2012) appear to be missing in the literature. Importantly, for all practices, details about their nature and their extents of implementation are either unclear or understood only for certain specific stakeholders. Given that facilitating practices not only directly improve environmental performance (Zhu et al., 2012), they also contribute to firms reaping these performance benefits from core green practices as well (Sarkis et al., 2011; Zhu et al., 2012), and therefore, a detailed understanding of them, and at an individual stakeholder level, is needed.

Overall, a comprehensive understanding of core and facilitating green practices including their extents of the implementation at an individual stakeholder level is not sufficiently understood for the construction sector. This understanding can guide practitioners on the 'what' and 'how much' of green practices' implementation and ultimately to greater green practice adoption across the sector. This leads us to our first research question:

- *What green practices (core and facilitating) are implemented by individual construction sector stakeholders and the extents of their implementation?*

Besides green practices, practitioners and policy makers also need to understand the antecedents or drivers and barriers of those practices; they can explain important aspects such as why some firms

implement a multitude of green practices or why the extent of implementation of these practices differs across firms. Here (green) drivers refers to forces that coerce/motivate firms to implement green practices; they could originate outside the firm (referred to as external drivers), such as from governments, non-government organizations (NGO's), competitors, other supply chain stakeholders and customers, or internally from within the firm (referred to as internal drivers) such as from corporate responsibility/concern for the environment and/or opportunity to reduce cost, improve brand image and market share (Walker and Jones, 2012). Similarly, (green) barriers refer to forces that limit/impede a firm from implementing green practices. These could again be of external origin (called external barriers) such as poor collaboration among stakeholders and lack of green suppliers, or of internal origin (called internal barriers) such as financial limitations which restrict the ability to make the required high investments in green practices and lack of skilled human resources that have the tools/ knowledge/experience of green practices (Walker and Jones, 2012).

What is important to know here for construction is the nature of all relevant external and internal drivers and barriers including each's perceived relevance/importance/strength. This knowledge could help practitioners and policymakers predict the sector's green behavior and devise strategies to maximize/leverage the drivers and minimize/eliminate the barriers in pursuit of green practice implementation. The underlying basis for this is the force field theory (Lewin, 1951) with opposing pressures of green drivers and barriers determining the extent of green practice implementation; higher the relative strength of drivers vis-à-vis barriers more can be the expected green practice implementation (in depth and breadth terms). The knowledge of drivers and barriers (as above) needs to be at the individual stakeholder (i.e. Developer, Architects/Consultant, Contractors/Sub-Contractor and Supplier) level so that driver and barrier management strategies could be customized to each case thereby ensuring sector-wide efficient and effective green practice implementation. However, when looking at the previous work (refer Table 1), studies that have investigated drivers and barriers in construction are itself quite a few. These studies are also either descriptive or generic, i.e. without stakeholder focus (Sourani and Sohail., 2011; Zhang et al., 2011; Liu et al., 2012), or have investigated drivers/barriers for specific green practices such as green purchasing and green construction only. Some important drivers appear to be missing as well. For instance, consumer pressure, which is identified as a key driver for greening in other sectors has seen little or no investigation in construction. Consumer pressure (for green buildings) can be expected to be significant given the significant energy and water savings as well as health benefits from non-use/less use of hazardous materials in such buildings (WGBC, 2013). This leads us therefore to the following research questions:

- *What are the drivers (external and internal) for implementing green practices (core and facilitating) for individual construction sector stakeholders and their strengths/relevance?*
- *What are the barriers (external and internal) faced by individual construction sector stakeholders to implement green practices (core and facilitating) and their strengths/relevance?*

The next important aspect is knowing the consequences or performance improvement/impact from green practices' (implementation), and which is relevant to decision making at all levels: strategic,

tactical and operational. However, this requires suitable (green) performance measures to be available. Performance measures in general help firms to evaluate and report performance, identify problems and bottlenecks, set new objectives and targets, determine future courses of actions and enable internal and external benchmarking (Gunasekaran et al. 2004; Björklund et al., 2012). Green performance measures related to environment (Zhu and Sarkis, 2004; Sarkis, 2011), cost/economic performance (Zhu et al., 2008; 2012; Green et al., 2012) and organisational performance (Green et al., 2012) have been discussed in other sectors with the latter two being particularly important from a business perspective (Buyukozkan and Cifci, 2012).

In contrast to other sectors, few studies have discussed green performance measures in construction (refer to the studies in Table 1). Among those few also, there is a lack of consensus: for example, on environmental performance measures, while Gangolells et al. (2009) have considered 20 sub-measures Fernández-Sánchez and Rodríguez-López (2011) consider only 12. This is also the case for cost/economic performance measures when comparing the works of Chen et al. (2010) and Fernández-Sánchez and Rodríguez-López (2011). These performance measures are also defined from an overall project perspective rather than from the perspective of individual stakeholders that would have been more practically relevant. Finally, none of the studies appears to have looked at organizational performance measures from a greening perspective. These measures consider the organization's corporate/brand image and resulting sales and market share implications of greening. They are critical to justifying investments in green practices which are significant in the case of the construction sector (WGBC, 2013). Overall therefore, adequate knowledge/understanding of green performance measures is not available for the construction sector. This would be making practitioners unsure about whether or to what extent to implement/invest in green practices thereby inhibiting the overall greening of the sector.

Having green performance measures alone is not sufficient though; also needed is evidence about the actual performance improvement/impact from green practices (through the application of these measures). This performance improvement/impact such as in the form of reduction in cost and/or increase in corporate/brand image with an attendant increase in sales/market share could motivate practitioners to implement/invest in green practices. Here again, very little work has been done in the construction sector. Only one study (by Jaillon et al (2009)) has demonstrated the environmental and economic benefits of green practices, but only for a specific green construction practice of pre-fabrication.

Therefore, in summary, more green practice implementation and at a (construction) sector-wide level requires a detailed understanding of the different performance measures and improvements/impacts in them from green practices' (implementation) at an individual stakeholder level. This understanding is not available at present and which therefore leads us to our next research question:

- *What are the green performance measures (in environmental, cost/economic and organizational terms) used by individual construction sector stakeholders and the extents of improvement in them from implementing green practices (core and facilitating)?*

While details about green practices, green drivers and barriers, and green performance measures and improvements/impacts are useful in their own right as discussed above, insights about interrelationships between some of them such as between green drivers/barriers and green practices' (implementation) and between green practices' (implementation) and performance could provide further value.

Individual green drivers and barriers could impact each green practice's implementation differently, and that too could vary across stakeholders. For instance, the positive/negative impact of a specific driver/barrier on a specific practice's implementation could be no/low, moderate or strong. Since firms are not entirely powerless in terms of their ability to manage, they could utilize this knowledge to identify and prioritize strategies for those drivers and barriers that have a strong and broad impact on green practices' implementation. Firms with knowledge of the one to one relationship between each driver/barrier and each green practice's implementation would therefore be able to better leverage the drivers and/or mitigate the barriers (in pursuit of green practices' implementation). However, this one to one assessment has not been done previously in the case of the construction sector. The review of previous work uncovered only one study (Qi et al., 2010) which discusses the relationship between drivers and green practices' implementation; however, no barriers and only select few drivers are considered, the relationship is not assessed one to one between a driver and a green practice's implementation and the focus is only on the Contractors. This leads us to our next research question:

- *How do or to what extent individual drivers (external and internal) and barriers (external and internal) impact individual green practice's implementation (core and facilitating) for each construction sector stakeholder?*

Finally, there is a need to understand the impact of individual green practice's (implementation) on each of environmental, cost/economic and organizational performance for each stakeholder in the construction sector. This understanding would enable practitioners to prioritize the implementation of those green practices that deliver the firm's targeted green performance goals (taking all three performance aspects into consideration). It would also enable firms to identify and make improvements (efficiency and effectiveness of implementation) to those green practices found to be lagging in delivering the desired green performance. Unfortunately, none of the previous studies on construction has looked at the relationship between green practices' (implementation) and green performance. This leads us to our final research question:

- *How do or to what extent individual green practice's implementation (core and facilitating) affects performance (in environmental, cost/economic and organizational terms) for each construction sector stakeholder?*

3. Methodology

This work being of an exploratory nature, a qualitative research methodology was considered. Information was gathered through semi-structured interviews (Miles and Huberman, 1994), with respondents (Senior Managers/Managers) profiled on the basis of their green knowledge/responsibility

in their respective organizations. Organizations were also chosen carefully so as to cover all key stakeholders, i.e. Developers, Architects/Consultants, Contractors/Subcontractors and Suppliers (of material). The semi-structured interview approach was preferred because the scope of the interviews (in line with our research objectives) revolved around four main aspects namely: green drivers, green barriers, green practices and green performance. Therefore, it enabled easy comparison of responses vis-a-vis the alternative unstructured interviews approach, which is susceptible to information overloading (Weller and Romney, 1988; Kvale, 2007). Moreover, semi-structured interviews allow for some degree of flexibility to explore new aspects within the main ones. Studies by Kvale (2007) and Rabionet (2011) were used as a basis to establish the ethical guidelines and the interview protocol. The detailed interview protocol used in this study is given in Appendix 1. Similar questions were posed to each respondent; they were of the nature of 'what', 'how', 'how much' and 'why to understand green drivers, green barriers, green practices and green performance and their interrelationships. A total of 31 interviews covering 21 organizations across UAE's construction sector were conducted over a six-month period. The demographic profile of the firms and respondents interviewed are provided in Table 2. Each interview lasted approximately 45 to 60 minutes. Most interviews were digitally recorded, and where this was not possible, detailed notes were taken that were later transcribed within one to two days and were also cross-checked with respondents to ensure accuracy. Further, wherever accessible, company documents including annual reports, newsletters, tender documents, internal performance/audit reports, and departmental publications were also sought to compliment the interview findings.

Table 2. Key Informants for interviews

Stakeholder	Size	Annual Revenues	Majority Ownership	Interviewee/s
Developer 1	Small	~$500 million	Local	Environmental Analyst, Manager (Community development)
Developer 2	Medium	~$900 million	Local	Environmental Manager, Manager (Waste), Head of Projects
Developer 3	Large	~$2 billion	Local	Senior Manager (Planning & Sustainability)
Architect/Consultant 1	Small	~$30 million	Foreign	Sustainability Specialist, Senior Architect
Architect/Consultant 2	Medium	~$150 million	Foreign	Head of sustainability
Architect/Consultant 3	Large	~$600 million	Foreign	Senior Consultant
Architect/Consultant 4	Small	~$50 million	Local	Consultant (Environment and Sustainability)
Architect/Consultant 5	Medium	~$200 million	Local	Senior LEED Consultant
Architect/Consultant 6	Large	~$500 million	Local	Director (Projects)
Main contractor/subcontractor 1	Small	~$90 million	Local	General Manager
Main contractor/subcontractor 2	Medium	~$450 million	Local	Senior Project Manager
Main contractor/subcontractor 3	Large	~$800 million	Local	Senior Manager(Tender), Manager (Business Development)
Main contractor/subcontractor 4	Small	~$75 million	Foreign	Technical Manager
Main contractor/subcontractor 5	Medium	~$300 million	Foreign	Project Manager
Main contractor/subcontractor 6	Large	~$550 million	Foreign	Sustainability Manager, Purchase Manager
Supplier 1 (Cement)	Small	~$20 million	Local	Senior Manager(HSE)
Supplier 2 (Steel)	Medium	~$125 million	Local	Production Head
Supplier 3 (Aluminum)	Large	~$2.3 billion	Local	Procurement Manager, Head of Quality, Head of Manufacturing, Manager(Quality and Production)
Supplier 4 (Gypsum, Cladding)	Small	~$25 million	Foreign	Production Manager
Supplier 5 (Cement)	Medium	~$150 million	Foreign	Operations Manager
Supplier 6 (Glass)	Large	~$800 million	Foreign	Senior QC Engineer, Head (Product Design)

Note: Very few foreign Developers are operative in UAE (Zawya, 2015), these are therefore not covered

The first stage involved thematic analysis of data for each stakeholder. The data drawn from the different interview transcripts and supporting company documentation across the four broad themes (green drivers, green barriers, green practices and green performance) were further classified into nine sub-themes namely external and internal drivers (1, 2), external and internal barriers (3, 4), core and facilitating green practices (5, 6), environmental, cost/economic and organizational performance (7, 8, 9) to better assess and manage these aspects (Walker and Jones, 2012; Zhu et al., 2012; Srivastava, 2007; Mohanty and Praksah, 2014; Seuring and Muller, 2008; Green et al., 2012). Codes were assigned to individual aspects identified within these sub-themes. For example, government regulation, identified as a driver of green practices was assigned a specific code within sub-theme 1 (external drivers). Similarly, environmental commitment, another driver identified was assigned a specific code within sub-theme 2 (internal drivers). Similarly, all the individual green drivers identified were assigned codes and categorised within sub-themes 1 and 2. The same procedure was repeated for green barriers, green practices and green performance for each stakeholder. Sub-codes were also used in certain cases. For instance, sub-codes were used to identify practices such as provision for natural ventilation, natural lighting, etc. within the green design (coded within core green practices sub-theme). This process of coding allows to link unit of data that refer to the same meaning. The existing literature in Table 1 also proved useful in developing the codes and sub-codes. The overall relevance/perceived importance of each sub-themes across each stakeholder was understood using high (H), moderate (M), and low (L) ratings.

The H, M and L rating for each core and facilitating green practice (discussed in Table 3 and Table 4 later) was obtained based on the information gathered from interviews and accessible company documents. The interviewees were asked to state the relevance of each practice to them; and if relevant, the extent of implementation of each green practice. Responses were assigned a score of 0 for no implementation, and 1 to 3 for the small, moderate and high extent of implementation respectively. For example, the extent of implementation of 'green design' was considered 'high' (on average across projects) for a Developer if it considers several green design aspects such as provision for natural ventilation, natural lighting, water recycling, renewable energy, green materials, etc. in their projects; while 'moderate' if it considers only a few green design aspects; and 'low' if it makes very less green design considerations. Accessible company documents were used to compliment/triangulate the interview findings and discrepancies (if any) found between the interview responses and company documents were sought and clarified with the interviewees. The scores obtained for each firm across each core and facilitating practice were aggregated to get the overall H, M and L for each stakeholder.

The H, M and L rating for drivers/barriers (discussed in Table 5 and Table 6 later) was obtained based on the number of mentions across all the interviews (occurrence and non-occurrence of a phenomenon) and the strength of opinions expressed by the interviewees (Saunders et al., 2012), which was assigned a score of 1 to 3 by the authors. For example, government regulation highlighted as a very important driver by all six respondents interviewed across Developer firms was given a score of 18 [6 (number of mentions) x 3 (strength of opinion)] out of the maximum possible 18 (6x3), which translates as high (H). Similarly, two out of the six Developer respondents interviewed highlighted stakeholder pressure as a green driver, but of low importance. In this scenario, stakeholder pressure was given a score of 2 (2x1)

out of the maximum possible 18 (6x3), which translates as low (L). The non-relevance of a driver/barrier for a stakeholder was also captured through the interviews.

Finally, the H, M and L rating for performance measures (discussed in Table 7 later) was obtained based on the information gathered from interviews and supporting company documents. The interviewees were specifically asked to comment on the relevance/non-relevance of environmental, cost/economic and organizational performance for their firms from a GSCM perspective; if relevant, they were asked to comments on the specific performance measures (such as reduction in carbon emissions, reduction in material costs, increase in market share) they deemed important across environmental, cost/economic and organizational performance dimensions; and their extent of improvement (overall). The extent of improvement for each firm across each performance dimension was assigned a score of 0 for no improvement, and 1 to 3 for small, moderate and high extent of improvement respectively. Again, accessible company documentation was used to compliment/triangulate the interview findings. Any discrepancies were sought and clarified with the respondents. In cases where no company documents were accessible or in cases where firms have no formal performance measures, judgement on the rating was based on the interviewee responses alone. The scores obtained from each firm were then aggregated to get the overall H, M and L for each stakeholder.

The second stage of the analysis involved identifying and assessing the important relationships between sub-themes (discussed in Table 8 and Table 9 later). Specifically, the respondents were asked to describe and discuss the relevant relationships between drivers/barriers and green practices; and green practices and each dimension of environmental, cost/economic and organizational performance. For example, between green drivers and practices, if the respondent highlighted government regulation as one the drivers for implementing green design and green purchasing practices; specific codes were assigned for the relationship between government regulation and green design and government regulation and green purchasing. Similarly, all the meaningful relationships highlighted by the respondents were coded. The strength of the relationships (strong (✓✓), moderate (✓) and no/low (empty cell)) in Table 8 and Table 9 was obtained based on the number of mentions across all the interviews and the strength of the opinions of the interviewees (similar to the methodology used to rate the drivers/barriers in Table 5 and Table 6) across each stakeholder.

4. Findings

In most cases, tables are used as they make it easier to relate the findings to the research questions. The following sections in sequence answer the research questions.

4.1. Green practices

Core practices: The relevant details for all the core green practices and their extents of implementation for all stakeholders was found. In the process, we have also found certain unique core green practices (which has not been discussed previously in the construction literature) such as environmental impact assessment which happens at the conceptual stage (before green design) and green transportation, which include both material and employee transportation within its purview. These core green

practices, as per construction supply chain stages, namely: (1) environmental impact assessment; (2) green design (include green building design relevant to Developers/Architects and green material design relevant to Suppliers); (3) green purchasing; (4) green transportation; (5) green construction (environmental friendly onsite construction relevant to Contractors)/ green manufacturing (environmental friendly manufacturing of materials relevant for Suppliers); and (6) end of life management; and the extents to which they are applied (in high, moderate and low terms) by different stakeholders are given in Table 3; related justification is also provided.

Environmental impact assessment (of projects), though not mandated by regulators, was found to be done by most Developers, Architects/Consultants, and Suppliers. Its importance can be gauged by the response of one of the Developer interviewee who said, "since our environmental impact is not only on land but also at sea, we have taken measures to ensure that aquatic or marine life is not affected by our project, even if it means relocation or building artificial reefs". From the perspective of green building design, one of the highlights is the fact the renewable energy generation from photovoltaic panels in their projects was found to be as high as 12-15% of a building's energy requirements in many cases for large Developers. With regards to green purchasing, for Developers, this is essentially in relation to purchasing of services (from Architects/Consultants and Contractors); purchase of (green) materials is done by Contractors, where the Developer's role is only to incorporate them in the (project) design. Contractors purchase services as well, which is from Sub-contractors, where again, green purchasing ideas are applied. As regards green transportation, it was found to receive significant consideration by the Contractors and, to a slightly less extent, by the Suppliers. From a manufacturing perspective, most of the materials produced consider green manufacturing aspects at most Supplier firms; green manufacturing was found to be beneficial, which in the case of a glass Supplier was able to reduce energy consumption by 30% and emissions by 40%. Finally, with regards to end of life management of buildings, while Developers and Architect's/Consultants role was found to be to develop designs that promoted end of life recycling and recovery of materials, that of Contractors was seen to revolve around energy efficient and planned demolition, including proper waste management to maximize recovery of materials.

As evident from Table 3, for the efficient and effective greening of any supply chain stage, each stakeholder must contribute by implementing complementary or at times overlapping green practices. However, what has emerged from the findings in Table 3 is that the extent of implementation of green practices is uneven in most cases, with some stakeholders demonstrating a greater extent of green practice implementation than others across each supply chain stage. For instance, the extent of implementation of green transportation practices is high for Contractors vis-à-vis Suppliers (moderate) and Developers (low) and Architects/Consultants (low). Significant responsibility awaits policy makers and industry leaders to take necessary actions to improve the green practices of stakeholders who lag others in implementing green practices. Nevertheless, the information about different green core practices in Table 3 is a useful starting point for practitioners across all stakeholders who are planning to implement these practices in their organization. It is also useful for firms to compare their current level of core green practice implementation vis-à-vis the industry level (high, medium, low) such that they may take corrective actions to increase their level of implementation.

Table 3. Core green practices and their extent of implementation

Core green practice	Developers	Architects/ Consultants	Main/Sub-Contractors	Suppliers
Environmental Impact Assessment	**High** • Done at the project concept stage and by most firms • Potential impact of project on natural habitat (flora & fauna) and air and water pollution assessed	**High** Do the actual assessment (alone or with the Developer)	**Not Relevant** *No involvement with projects at this stage*	**Moderate** Potential impact of project on noise levels, air quality and water sources assessed; mostly done by large firms & foreign firms
Green design	**High** • Emphasised in government regulations, LEED/ BREEAM certifications; practices applied vary across projects • Aspects considered: Natural lighting and ventilation, use of water saving technologies, use of green materials, reduced use of hazardous materials and energy consumption based designing • Additional aspects considered by large firms incl. use of photo-voltaic panels & more recyclable materials (to increase recovery at end of life), modular design (for ease of disassembly), pre-fabrication & waste water recycling	**High** • Actually develop the designs incl. green related as required by the Developer • Better capabilities at foreign firms; are able to access the centrally (at HQ) available tools and expertise	**Not Relevant** *No involvement in design incl. green-related; enter after finalisation of design which they have little authority to change*	**Low** • Relevant aspect is (green) material design • Green material offering is standard rather than customised to individual customer/project requirements; green material sales constitute only a small proportion of total sales
Green purchasing	**Moderate** Essentially in relation to purchase of services (materials purchase is typically by Contractors), which are purchased from Architects/Consultants & Contractors, in whose selection, green-related criteria are applied as below: • At pre-qualification stage: LEED certified staff in rolls + track record on LEED projects (for Architects/ Consultants) and EMS and ISO14000 certification (for Contractors) • At selection stage: 10-30% weight to green consideration in design (for Architects/Consultants) and to environment & waste management plan (for Contractors); Small firms ~10% weightage, large ones ~ 30% weightage	**Not Relevant** *No direct involvement in purchasing*	**Moderate** • Is in relation to materials & service purchases from Suppliers & Sub-Contractors respectively • Smaller firms: purchase of green materials is entirely as per the contractual requirements (of the Developer) • Large local and all foreign firms: exceed Developer's contract requirements such as on green material specifications, auditing suppliers (for green), considering LEED experience & no. of LEED certified staff in rolls for sub-contractor selection as well as making EMS and ISO 14001 mandatory for them	**Low** The green input material purchase is as per the green material demand, which constitutes only a small part of the total material demand.
Green transportation	**Low** No significant consideration from both material as well as employee (transportation) perspectives, and at own as well as downstream stakeholders	**Low** Local firms: No significant consideration; Foreign firms: Use video conferencing to minimize employee travel and thereby emissions	**High** • Preference for full truck load transportation, use of fuel efficient vehicles and employee accommodation near project sites • Large local and all foreign firms: additional practices such as choosing geographically closer suppliers (less material travel) and scheduling material deliveries during periods of less traffic congestion (lower fuel consumption, lesser emissions)	**Moderate** • Full truck-load transportation to minimise emissions is common • Use of other emission control practices varies; these incl. choosing geographically closer suppliers, choosing low-emitting transport modes, considering traffic congestion when planning deliveries, locating employees near manufacturing sites and sharing transportation
Green Construction/ Manufacturing	**Not Relevant**	**Not Relevant**	**High** • Automated (and therefore less waste generating) & energy efficient machinery used • Waste segregated to enable its reuse/recycling • Pre-fabrication used (to reduce onsite waste)	**High** State of the art equipment that consumes less energy, causes less emissions and lower (manual related) wastage/ errors used for manufacturing all materials in most firms
End of Life Management	**Moderate** • No specific regulations for this • Not considered by small firms; large firms consider related design aspects like modular design (for easier disassembly), and use of more recyclable materials (to enable their reuse at end of life), though which varies across projects	**Moderate** Actually develop the relevant end of life designs; Better tools, expertise with foreign firms	**Moderate** • No specific regulations for this • Practices include use of energy efficient demolition equipment, selective dismantling of buildings, segregation of demolition waste and safe disposal of hazardous materials	**Not Relevant**

Facilitating practices: For each stakeholder, the relevant details of all the facilitating green practices namely (1) environmental management systems (EMS) and ISO 14001 certification; (2) environmental training; (3) environmental auditing; (4) cross-functional integration; (5) green-related research and development (R&D); and their extents of implementation (in high, moderate and low terms) was found. The details are given in Table 4. Among the practices found, green-related R&D emerged as a unique facilitating green practice (which has not been discussed previously in the construction literature).

As can be seen in the table, the EMS's application was found to be extensive across stakeholders with most firms (more than two-thirds) being found to be 1SO 14001 certified as well. The extensive use of EMS shows that in most firms (across stakeholders), environmental programs are managed in a comprehensive, systematic, planned, and documented manner (Ofori et al., 2002). Moreover, the ISO 14001 certification indicate conformance to high international standard. Environmental training was seen as useful to greening by all the stakeholders interviewed, though a difference in the nature of training provision (e.g. own employees only or other stakeholder's employees also, all employees or select employees) was observed. This was found to be true for environmental auditing as well. As regards cross-functional integration, the extent of this integration was found to vary across stakeholders (as can be seen in the table); for Architects/Consultants and Contractors, this integration was seen to be more among foreign than local firms, both across departments within the firm as well as with the overseas headquarters. The latter enables swift transfer of green knowledge as captured in the statement of one respondent: "The good thing with us (a foreign Contractor) is that we have inherited the entire EMS and other systems from our head office." Finally, R&D was found to be particularly intensive at the Suppliers, where, as per the respondents, it has resulted in the development of many state of the art materials and technologies; this includes, a patent pending glass window technology for buildings that converts 90% of the solar radiation falling on its surface into electricity for a glass manufacturer. It is important to clarify that while both green design and green related R&D in the case of Suppliers pertain to material design, the former is more from an operational perspective, with the latter being more from a strategic and long-term perspective.

Overall, as evident from the Table 4, all the identified facilitating green practices are relevant for all stakeholders. Unlike core green practices, the extent of implementation is fairly consistent across different practices except for green-related R&D, which was found to be uneven across stakeholders. From a practitioner's perspective, this significantly improves the understanding of the important facilitating green practices that each stakeholder must implement and the extent to which they must implement to be competent in the sector. For example, a Supplier with no or limited green-related R&D, the findings should provide the impetus for them to implement or improve their current R&D practices so that they don't fall behind other Suppliers in the sector, which overall was found to be high.

Table 4. Facilitating green practices and their extent of implementation

Facilitating green practice	Developers	Architects/ Consultants	Main/Sub-Contractors	Suppliers
Environmental Management System (EMS) and ISO 14001	**High** EMS, and which is ISO14001 certified, is implemented at most firms	**High** Most firms have EMS; a sizeable proportion of these also have ISO14001 certification	**Moderate** A good proportion of firms have EMS among which a good proportion have ISO 14001 certification also	**High** EMS and with ISO14001 certification is operational in most firms
Environmental training	**High** At most firms • Dedicated in-house training department which also imparts environmental training • Training provided to both own as well as Contractor's & Supplier's employees At large firms: Longer i.e. ~ months and broader i.e. curriculum based training; At small firms: usually day/ week long training	**High** • Extensive environmental training is provided to employees at most firms; In a significant proportion of firms this training is also provided to Contractor's & Supplier's employees • Most firms are also providing opportunities to their employees to gain LEED /other international certifications	**Moderate** • Training is provided mostly to own employees • At foreign firms the content of training programmes is comprehensive and which is imparted to employees at all levels; At local firms the training is more on waste minimisation practices and is limited to onsite workers	**Moderate** • Training is provided predominantly to own employees • Training is usually on operational aspects of manufacturing such as on improving plant efficiency and reducing waste and pollution
Environmental auditing	**High** Done by most firms and includes both internal as well as external auditing (of other stakeholders)	**High** • Done by most firms • Both ongoing projects as well as suppliers are audited	**Moderate** • Large local and all foreign firms: do both internal as well as external auditing (of suppliers); internal auditing at foreign firms is more stringent in line with the firm's global/ headquarter requirements • Small and medium local firms: do only internal auditing	**Moderate** Mostly limited to internal auditing
Cross-functional integration	**High** • At most firms, cross-functional teams from sales, purchase and environmental departments work together from project conceptualisation to completion and handover • Cross-functional teams ensure good cooperation between their respective departments; enable realisation of the firm's environmental vision and mission	**Moderate** Significant difference between local and foreign firms • Foreign firms: Emphasis on cross-functional teams both within the firm and with head office; organisation structure (decentralised) and culture both support formation of teams • Local firms: No/limited use of cross-functional teams	**Moderate** Significant difference between local and foreign firms • Foreign firms: Significant use of cross-functional teams; supportive structure and culture • Local firms: Limited cross- functional integration; hierarchical organisation structure is a hindrance	**High** • Cross functional teams from sales, purchase, operations, manufacturing, research and development and environmental departments used • Teams work together on all green-related projects
Green-related Research and Development (R&D)	**Low** Limited emphasis with no dedicated budget; prefer getting best practices from other countries	**Moderate** • Foreign firms have a large budget with many researchers working on green design techniques and solutions • No dedicated budget and limited effort at local firms	**Low** Limited emphasis with no dedicated budget; favour getting best practices from developed countries instead	**High** • Significant emphasis in most firms in anticipation of future potential (of green materials) • Contributes significantly towards developing innovative materials

4.2. Green drivers

We have found the relevant details for all the green drivers (including the unique ones) and their perceived strengths in relation to (all) green practices implementation for all stakeholders. The details of these drivers and their perceived relevance/strengths are given in Table 5. The presentation in the table is split in terms of external drivers (refer rows one to four) and internal ones (refer rows five to eight).

External drivers: Pressure exerted by government green regulations were found to be an important green driver for Developers and Contractors to whom these regulations only apply in the UAE at present. With regards to stakeholder pressure (as a green driver), the Developer is considered to be the key stakeholder; in the words of one interviewee, "If it is environmental performance, the primary driver is the Developer, otherwise, neither the Contractor nor the Consultant will bother to implement any green practices." This pressure from the Developer then passes down the hierarchy up to the Suppliers who were found to consider it only as a moderately strong green driver; this is reasonable given that green requirement from Suppliers such as on the use of recycled materials and non-use of hazardous substances are quite consistent, and therefore less onerous to fulfil. As regards competitor pressure as a green driver, the large number of LEED certified projects coming up in the UAE (from 1 in 2011 to more than 900 in 2015 according to LEED, 2015) are putting pressure on Developers to develop similar projects. The Architects/Consultants and Contractors too were found to face competition from the many overseas firms that have entered the UAE with advanced green knowledge/capabilities (as reflected in the 25% increase in foreign direct investment in UAE's construction sector in the last few years reported by TFG, 2015). While local firms, particularly small ones, were found to face greater competitor pressure to implement green practices, not surprisingly so, given that thousands of them compete for 50% of the market (Oryx, 2013), for foreign-owned firms, this pressure was lower, and justifiably so, given their advanced green knowledge. For Suppliers, competitor pressure was not found to be a strong green driver, which is understandable given that there are only a few local supplier firms so that competition, in general, is itself low; for example, there are only three local manufacturers for each of aluminium and cement (Zawya, 2016). Finally, consumer or end customer direct engagement is with the Developer only; consumer pressure on greening was therefore rightly found to be relevant to Developers and not the other stakeholders, this pressure being (observed to be) low though. This can be explained as due to most consumers' lack of awareness of the cost and health benefits of green buildings (WGBC, 2013) given their predominantly South Asian origins where issues related to the environment are just emerging. Another factor is their limited ability/preference to pay the premium for green/LEED buildings (REISS-MENA, 2012) given their lower socio-economic strata. It should be noted that consumer pressure as a green driver has not been previously discussed for construction and therefore constitutes a novelty. With regards to other green drivers discussed in the literature, non-government organization (NGO) pressure on greening does not work in the UAE, as there are only a few NGO's who also do not enjoy any legal backing; similarly, no incentives or subsidies for greening are provided there unlike in countries such as China and Hong Kong (Zhang et al., 2011; Jaillon et al., 2009).

Internal drivers: While Table 5 provides most of the details, a few additional points are as follows: (1) In relation to environmental commitment as a green driver, most Developer firms were found to have a comprehensive environmental policy thereby demonstrating this commitment. This policy was found to

Table 5. Green drivers and their relevance/strength perceived by stakeholders

External Drivers	Developers	Architects/Consultants	Main/Sub-Contractors	Suppliers
Government regulations	**High** • Stringent regulatory pressure (Dubai Green Building Regulation, ESTIDAMA in Abu Dhabi, EHS Trakhees in Free Zones) • Strict enforcement and stringent fines for non-compliance	**Low** No regulations	**High** Stringent regulations, which require: • At least 50% of the waste generated to be recycled/reused (instead of being landfilled) • Environmental management system (mandatory) • A construction and waste management plan (CWMP) as per prescribed format in advance of operations commencement	**Low** No regulations
Stakeholder pressure	**Low** Other stakeholders have little influence	**High** Pressure essentially from Developers who: • Require support to meet the green regulatory or LEED/ BREEAM certification requirements • Assess green-related expertise and experience when awarding contracts		**Moderate** • Pressure from Consultant and Contractor to meet green material requirements • Pressure from Contractor to sign the UN Global compact (to demonstrate sustainability) and to install EMS
Competitor pressure	**High** Increasing trend among firms to develop LEED/BREEAM certified projects	**High** Increasing influx of foreign firms with advanced green knowledge and capabilities		**Low** Few firm's operatives in the country; competition in general is low
Consumer pressure	**Low** • Consumer has limited awareness and appreciation of green (projects) • Consumer lacks affordability	**Not Relevant** *No direct interaction with consumers*		
Internal Drivers				
Environmental commitment	**High** Most firms have: • A comprehensive corporate environmental policy • Good top, middle and operational management support for green	**Moderate** • High for foreign and large local firms: on account of (comprehensive and stringent) environmental policy at HQ; to lower risks to reputation from environmental accidents • Low for small/ medium size local firms: Less focus on environmental aspects and more on economic returns		**High** A significant proportion of firms have: • Sustainability in their vision and mission statements • A carbon mgmt. strategy with targets • A sustainability report published annually
Enhance reputation/brand image	**High** • To be attractive to foreign investors • To improve relationship with government construction bodies • To sell projects faster; to sell projects at a premium, if possible	**Moderate** • High for all foreign and large local firms: So as to win projects from environmentally reputable Developers; to be able to charge a premium • Low for small and medium sized local firms		**High** • To be able to increase exports • To convince Consultants to include their materials in the tender specification • To charge a premium
Cost savings	**Not Relevant** No direct cost savings		**High** Reduction in onsite construction costs, specifically material, labour, transportation & landfill costs; shorter project completion times also with some practices (e.g. pre-fabrication)	**High** Significantly lower energy, water and waste processing costs with green manufacturing
Enter foreign markets	**High** • Green-related regulations of foreign markets need to be met • Green credentials like LEED gold/ platinum certification necessary for impressing foreign clients/investors	**Moderate** •High for foreign firms; participate in neighbouring countries' tenders using UAE as the base • Low for local firms; UAE focussed	**Moderate** • High for all foreign and large local firms; participate extensively in global tenders • Low for small and medium sized local firms; mostly UAE focussed	**High** Materials need to have green attributes for successful exports

include guidelines on lowering pollution, using natural resources, climate change based investment decisions, environmental training, and meeting stakeholder's environmental expectations, with the key statements in some cases reading as "committed to protecting the environment and ensuring sustainability of our communities" and "committed to carrying out all activities in an environmentally sustainable way"; (2) Clear evidence of reputation/brand image as a green driver was observed for one Contractor interviewee, in whose case the significant media coverage and recognition for (its) waste reduction efforts resulted in many Developers approaching it for business; (3) With regards to cost savings (from green practices) as a driver, it is important to point out that for a construction project, this is possible either during the construction phase (relevant to Contractors/Sub-contractors) and/or during the use phase (in the form of energy, water, and other savings that accrue to owners/tenants); cost savings was found to be a significant driver for all the Contractors interviewed, with an interviewee from a large UK-based Contractor firm highlighting how it was able to save £0.15 million from a single project through green construction practices; (4) finally, the ability to enter foreign markets such as Middle East, North Africa, the UK and the US was identified as a significant green driver by Developers and Suppliers; among others, the Developer deriving 20% of its revenues from US based projects and the Supplier exporting to 54 countries including the US and the UK were found to be the most engaged in green practices. Entry into foreign markets as a green driver has not been previously discussed in any sector and hence contributes to the body of green knowledge.

The findings are important for practitioners to first understand the various external and internal drivers and then assess the importance attached by their firms to each of these drivers vis-à-vis the sector so that actions could be taken to leverage these drivers to stay competent in the sector. For example, for firms attaching low importance to government regulation could face the risk of compliance fines and penalties and delays in project approval. From a government perspective, the findings are useful to get a snapshot of all the external and internal drivers and their perceived importance such that they could take necessary actions (such as regulatory changes, public awareness campaigns on the benefits of green buildings) to enhance these drivers.

4.3. Green barriers

For all stakeholders, we have found the relevant details of all the green barriers (including the unique ones) and their perceived strengths in relation to (all) green practices implementation. The details of these barriers and the perceived strengths are given in Table 6. The presentation in the table is split in terms of external barriers (refer rows one to four) and internal ones (refer rows five to six).

External barriers: The shortages of green professionals and local green suppliers (as green barriers) are discussed in the first two rows of the table. With regards to the latter barrier, among other things mentioned in the table, the interviewees pointed to the fact that it causes green material imports which increase environmental emissions due to the additional transportation involved; in the words of one Developer interviewee, "By the time the green materials reach here (the UAE) from overseas, they are already brown." Tight and inflexible deadlines were identified as a unique barrier not seen in the

Table 6. Green barriers and their relevance/strength perceived by stakeholders

	Developers	Architects/Consultants	Main/Sub-Contractors	Suppliers
External Barriers				
Shortage of green professionals	**High** • Local universities, colleges and training centres offer few courses on green/sustainable architecture and construction • Opportunities provided by the government for professionals to acquire green certification has had only a limited success			**Low** Greening is equipment/technology dependent (on which staff are trained in-house) & (green) input materials
Shortage of local green material suppliers	**High** • Project costs are higher as green material has to be imported, which, on account of the transportation involved, is more expensive • Project delay risks are higher due to uncertainties associated with imports (of green material that are required) • Project green /environmental objective is compromised: the transportation associated with green material imports (that are required) mean more emissions	**Moderate** Design changes have to be made to cope with project cost and time escalation caused by the uncertainties associated with green material imports (that are required)	**Moderate** • High for local firms: Have to establish relationships and get good credit terms from foreign suppliers which is challenging; also, causes green materials to be imported thereby making them more expensive and delay prone (due to the transportation involved) • Low for foreign firms: Are able to tap into their global level arrangements with green material supplier firms to get competitive prices, good credit and delivery terms & with less risk of delays	**Low** Adequate green input material supplies are locally available
Tight and inflexible stakeholder deadlines	**Low** • Have control over how green & speed (or deadlines) are to be balanced though: 1) Demand for buildings in UAE is outstripping supply necessitating faster completions, 2) Green building planning & preparation takes more time than a conventional building	**High** • The deadlines in line with the quick project completion requirements come from the Developer and which are enforced with penalties • Green building design takes more time than a conventional one (for Architects/ Consultants); similarly, for Contractors, site preparation, waste management and other green practices take (additional) time. With tight and inflexible deadlines therefore, green practices tend to get compromised		**Low** The green materials produced/ supplied are generally standard rather than customised
Lack of stakeholder collaboration	**Low** Have control over the nature and extent of collaboration with (downstream) stakeholders	**Moderate** Trust deficit with Developers (the relevant stakeholder) due to: • Project awards by them being one-off rather than in a long-term relationship mode • Non-sharing of green-related knowledge by them due to fear that it could be leaked to competitors Green designing effectiveness is compromised as a result	**High** • Trust deficit with Developers due to project awards by them being one-off rather than in a long-term relationship mode; causes misunderstanding and lack of flexibility on green related responsibilities and solutions • Trust deficit with Architects/Consultants; they do not provide complete information on important aspects such as constructability & environmental impact due to fear that their role could be taken over in future; green-construction-related planning is made more difficult as a result	**Low** Generally standard green materials produced and supplied; collaboration is not therefore considered critical
Internal Barriers				
Lack of knowledge and awareness of green practices	**Moderate** • Overall knowledge is reasonable; needed to appreciate regulations & competitor actions • Knowledge of environmental performance measurement/ monitoring though is limited	**Low** Almost all firms have LEED certified employees in their rolls	**Moderate** In most firms, good knowledge and awareness at the corporate level; at the project manager level though, the knowledge varies & adversely affects onsite green practices application where low	**Low** Knowledge is kept up-to-date (through training programs) to facilitate research & development of new green materials
High cost of implementation	**High** Green projects significantly more expensive than conventional ones: (green) material costs and architectural and consulting fees are higher; there are additional costs (of equipment's such as recycling systems & solar panels and of LEED /BREEAM certification)	**Moderate** • High for local firms; low for foreign firms (able to use HQ or centrally available resources) • Key costs: cost of green design software, EMS & ISO 14001 and of LEED/ BREEAM professionals	**Moderate** • Low for all foreign & large local firms as this cost is only a small proportion of their total costs; foreign firms also leverage global knowledge base and tie-ups; high for small & medium sized local firms • Key costs: Automated equipment (concrete mixers, spreaders) to reduce onsite waste, EMS& ISO14001	**High** • Green materials manufacturing equipment/tech. is expensive • Green input materials are more expensive than conventional ones • Significant R&D investments needed to develop green materials

previous green literature, and which was identified as a significant or a high strength barrier by Architects/ Consultants and Contractors. Its adverse impact on greening can be gauged by the response of one Contractor who said, "We were given only 24 hours to clear the site upon project completion; we couldn't segregate the waste and had no option other than to send the waste to the landfill." Finally, the lack of stakeholder collaboration and its adverse implication on greening was evident through the experience of one Contractor interviewee who was not allowed to use recycled concrete (a green material) that had become available only because it was not specified in the contract. While the relevance of stakeholder collaboration in the context of greening the construction sector has been discussed earlier (Sourani and Sohail, 2011), it was limited to purchasing rather than from a sector-wide perspective as is done here.

Internal barriers: These are lack of knowledge and awareness of green practices and the high cost of implementation (of green practices), which are presented in the bottom two rows of Table 6. Knowledge and awareness of green practices were rated as a low to moderate strength barrier by different stakeholders, which is in contrast to the findings in some of the previous studies (Zhang et al., 2011; Shi et al., 2013) where it was found to be a high strength barrier. One explanation for this could be the increase in the green/sustainability conference, workshop, and seminars organized in the UAE with the support of the UAE government and leading industry players. With regards to the cost of green practices implementation, it is considered to be significant and therefore rated as a moderate to high strength barrier by all the stakeholders. This is in line with previous findings (Lui et al., 2012; Shi et al., 2013). In the Developer's case, among the costs of implementing green practices highlighted in Table 6, the (high) cost of green materials is considered as the most significant; these materials are 15-20% more expensive than conventional materials (Future Build, 2016). The response from one of the interviewees was therefore not surprising: "we Developers need to fetch a higher price for green buildings, otherwise the benefits of such projects would largely be enjoyed by the end user." In the case of Suppliers too, the cost of green practice implementation is considerable, and on multiple accounts, as can be seen in the table.

The findings are important for practitioners, policy makers and industry leaders to understand the various impediments that lie within or outside a firm in green practice implementation. The findings could help the sector to prioritize efforts in minimizing those barriers first which have broad impact across all stakeholders. For example, barriers such as high cost of implementation significantly affect the green practices implementation of all stakeholders, while others such as lack of knowledge and awareness affect the implementation of only a few stakeholders. Also, the findings show that certain stakeholders such as Contractors face more challenges than other stakeholders such a Suppliers. From a stakeholder perspective, it helps identify and prioritize counter measures to negate the impact of relevant barriers.

4.4. Green performance

Table 7 provides the relevant details found for all three green performance measures namely:

Table 7. Green performance (measures and extent of improvement)

		Developers	Architects/ Consultants	Main/Sub-Contractors	Suppliers
Environmental Performance	Sub-measures used	Energy and water consumption and number of environmental accidents used at most firms and as required by regulations; additional measures for LEED/BREEAM projects as per the respective certification requirements	Water and energy consumption and quantity of air emissions (that are estimated) used, but only for a few most environmentally friendly projects	• Amount of air emissions, use of hazardous materials, material, energy and water consumption, waste landfilled and number of environmental accidents used at large local and all foreign firms, though with the exact measures being different • Waste generated & landfilled and number of environmental accidents used at small and medium sized local firms (regulatory reqmt.)	Amount of air emissions, use of hazardous materials, material, energy and water consumption, waste landfilled and number of environmental accidents used at most firms
	Extent of improvement from green practices	**High** Lower water and energy consumption and fewer environmental accidents at most firms; used in subsequent sales pitches to prospects	Improvements in the above assessed once (after a few months of project completion) based on data provided by Developers; used in subsequent sales pitches	**Moderate** • Overall improvement for large local and all foreign firms with more improvement for the latter • No improvement at small and medium sized local firms	**High** Overall improvement at most firms
Economic/Cost Performance	Sub-measures used	Material cost and amount of environmental fines used at most firms	At most firms, no separate measures or monitoring of green projects	• Material cost, energy and water cost, waste treatment cost and environmental fine amount used at large local and all foreign firms, though with the exact measures being different • No measures used at small and medium sized local firms	Material cost, energy and water cost, waste treatment cost and environmental fine amount used at most firms
	Extent of improvement from green practices	**Nil/Low** For many firms: • Material cost is higher; higher unit cost (for green materials) dominates reduced material requirement (from green practices) • No significant impact on amount of environmental fines; already quite low having been reduced over time		**Moderate** • Lower cost in overall terms for large local and all foreign firms and particularly lower for the latter • No change in overall cost for small and medium sized local firms	**High** All the above costs are lower for most firms except material cost (which is higher)
Organizational Performance	Sub-measures used	Sales, market share, profit and return on investment used at most firms	Number of projects awarded, market share and profits, which are used at most firms	Number of projects awarded, market share, profits and return on investments, which are used at most firms	Sales, market share, profits and return on investments, which are used at most firms
	Extent of improvement from green practices	**High** For most firms: • More (project) sales and gain in market share • No significant improvement in profits; premium on green buildings difficult to get & which barely recovers the additional costs incurred • Significant improvement in return on investment (due to reduced cost of capital on account of firm's enhanced rating and attractiveness)	**High** For most firms: • Increase in the number of projects awarded • Gain in market share • More profits (higher fee realisation more than compensating for higher costs) • Higher return on investment which is only in perception terms as not formally measured	**Moderate** • For most foreign firms: More projects awarded, gain in market share and profits, the last through higher fee realisation for green projects and lower costs from onsite green practices and despite the higher costs of (green-related) equipment; the return of investment is also higher • Lower performance (in relation to foreign firms) in each measure for large local firms; even lower performance for small and medium sized local firms	**High** For most firms: • More sales and gain in market share • More profits from premium pricing and lower (green) manufacturing costs, though partly offset by higher input (green) material costs & the higher cost of (green) equipment • Higher return on investment, but only moderately so, due to the significant investments made on green manufacturing equipment and green-related R&D

environmental; economic and organizational across all stakeholders as well their extents of improvement from (all) green practices implementation are provided. In the table, the upper half of each cell provides the important measures being used/suggested by stakeholders in the UAE. As evident in the table, the sub-measures used/suggested vary across stakeholders for environmental and economic performance, while the sub-measures used/suggested are fairly consistent for organizational performance. This makes sense as organizational performance is from a strategic/business perspective while the others are more operational in nature. With regards to environmental performance, the Developers are required by law to monitor and report the energy and water consumption of buildings to the government even after these have been sold off to end-customers. This is to verify if the energy-efficient designs actually work in practice or not; it also helps Developers in assessing/improving their designs. Developers are also required to monitor the number of environmental accidents. Other measures and sub-measures used by Developers, as well as those for other stakeholders, are clear from the table. This understanding could help firms to develop better performance measures to help them evaluate and justify investment in green practices.

Table 7 also provides the extent of improvement in performance from green practices (lower half of each cell), as assessed on the basis of actual (performance) data and interviewee perceptions; it is in high, moderate and low terms and is provided for each performance measure and for all the stakeholders. With regards to extent of improvement in environmental performance (from green practices), it was found to be high for Developers and Suppliers; one aluminium Supplier was found to have been able to reduce its chlorofluorocarbon (CFC) emissions by 50% and waste generation by 10% over two years through green practices; similarly, a glass manufacturer could reduce its CFC emissions by 60% and energy consumption by 30% through these practices. Suppliers were found to have significantly improved their cost performance as well from green practices; for those interviewed, energy costs had reduced by 8%-40% and water costs by 5%-10% through these practices. Other performance improvement related details for Suppliers, as well as those for other stakeholders, are clear from the table. A novel and important finding (which has not been assessed previously in the construction literature) is the fact that implementation of green practices has resulted in improvement in organizational performance across all stakeholders. This should provide the impetus for firms to consider GSCM from a long-term strategic viewpoint.

4.5. Relationships between green drivers, barriers, and green practices

In Table 5 and Table 6 the perceived relevance/strength of green drivers and green barriers was discussed. Given that an organisation-wide greening or an all-green-practices application perspective is taken at the corporate level, such a relevance/strength information would therefore apply at that level; all green drivers and barriers would be relevant for managerial intervention, though corporate managers may choose to focus on only the high and moderate strength ones for leveraging (for drivers) and/or mitigation (for barriers) in relation to greening. On the other hand, at a functional/departmental level, the focus typically is on specific green practices. Knowledge of green drivers and barriers (i.e. their relevance and strength) here would therefore need to be from the perspective of individual green practices' (implementation) so that managerial intervention at an operational/ implementation level can be appropriately focussed.

Table 8. Relationships between green drivers, green barriers and green practices

	External Drivers			Internal Drivers				External Barriers				Int. Barriers		
	Government Regulations	Stakeholder pressure	Competitor Pressure	Environmental Commitment	Enhance reputation/Brand	Cost savings	Enter foreign markets	Shortage of green professionals	Shortage of local green material suppliers	Tight and inflexible stakeholder deadlines	Lack of stakeholder collaboration	Lack of knowledge and awareness of green pr.	High cost of implementation	Green Practice (Extent of application as per Table 3 and 4)
Developer			✓	✓	✓		✓	✓				✓	✓	Env. impact assessment (High)
	✓✓		✓✓	✓	✓✓		✓	✓	✓				✓✓	Green design (High)
	✓		✓	✓✓	✓		✓	✓				✓	✓	Green purchasing (Moderate)
												✓✓		Green transportation (Low)
			✓	✓	✓		✓	✓				✓	✓	End of life management (Moderate)
			✓✓	✓✓	✓✓		✓✓	✓				✓	✓	EMS & ISO 14001 (High)
			✓	✓✓	✓			✓				✓	✓	Environmental training (High)
			✓	✓✓	✓			✓				✓	✓	Environmental auditing (High)
				✓✓	✓									Cross-functional Integration (High)
								✓✓				✓✓		Green-related R&D (Low)
Architect/ Consultant		✓✓			✓		✓	✓		✓	✓			Env. impact assessment (High)
		✓✓	✓✓	✓	✓✓		✓✓	✓	✓	✓✓	✓		✓	Green design (High)
				✓										Green transportation (Low)
		✓✓	✓		✓		✓	✓		✓	✓			End of life management (Moderate)
		✓✓	✓✓	✓✓	✓✓		✓✓	✓					✓	EMS & ISO 14001 (High)
		✓	✓	✓	✓		✓	✓			✓		✓	Environmental training (High)
		✓	✓	✓	✓		✓	✓			✓		✓	Environmental auditing (High)
			✓	✓										Cross-funtl. Integration (Moderate)
			✓	✓	✓		✓	✓			✓		✓	Green-related R&D (Moderate)
Main/Sub-Contractor		✓✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	Green purchasing (Moderate)
				✓✓	✓	✓						✓✓	✓	Green transportation (High)
	✓✓	✓✓	✓	✓	✓	✓✓	✓	✓✓		✓	✓	✓	✓	Green construction (High)
		✓	✓	✓	✓			✓		✓✓	✓	✓		End of life management (Moderate)
	✓✓	✓✓	✓	✓	✓		✓	✓				✓	✓✓	EMS & ISO 14001 (Moderate)
		✓	✓	✓	✓		✓	✓				✓	✓	Environmental training (Moderate)
		✓	✓	✓	✓		✓					✓	✓	Environmental auditing (Moderate)
				✓		✓						✓		Cross-funtl. Integration (Moderate)
												✓	✓	Green-related R&D (Low)
Supplier				✓	✓								✓	Env. Impact assessment (Moderate)
		✓		✓	✓		✓						✓	Green (material) design (Low)
				✓									✓	Green purchasing (Low)
				✓	✓									Green transportation (Moderate)
				✓✓	✓✓	✓✓	✓✓						✓✓	Green manufacturing (High)
		✓✓		✓✓	✓✓		✓✓						✓	EMS & ISO 14001 (High)
				✓	✓		✓						✓	Environmental training (Moderate)
				✓	✓		✓						✓	Environmental auditing (Moderate)
				✓✓	✓									Cross-functional Integration (High)
				✓	✓✓		✓✓						✓✓	Green-related R&D (High)

From the interview responses, individual green driver and barrier's relevance/strength vis-a-vis each green practice's implementation was assessed (terms of high, moderate and low or negligible strength); this was done for all green practices for each stakeholder. The results are presented in Table 8. The table also includes the extents of application of individual green practices by stakeholders (in high/moderate/low terms), which are repeated from Table 3 and Table 4 so that firms looking to improve any specific green practice can quickly get a sense of all key drivers and barriers impacting the implementation of that green practice and therefore could choose to decide on prioritizing actions for maximizing/leveraging all or select green drivers or/and minimizing/eliminating all or select green barriers that impacts that green practice.

Some of the other key aspects, also apparent from Table 8 include:

- Some green drivers, such as regulations and cost savings, affect the implementation of only a few green practices and for select stakeholders, while there are others, like environmental commitment and enhance reputation/brand image, where the effect is on several green practices' implementation, and for many stakeholders. A similar contrast is seen for the barriers as well.
- Some green practice (such as green design for Architects/Consultants and green construction for Main/Sub-contractors) implementation is influenced by several drivers and barriers; much careful thought, therefore, would be needed when considering applying such practices. Others, such as green-related R&D for Developers and green transportation for Suppliers are however influenced by only a few green drivers and barriers, and therefore would be easier to decide on their implementation.
- The extent of implementation of a green practice depends on the net of the opposing pressures of (its) green drivers and barriers, where both numbers and strengths of the drivers and barriers are relevant. This can be seen for example, in the cases of i) Green design for Developers, where green drivers dominate barriers, both in number and strength terms and the level of implementation of the practice is high; ii) Green-related R&D for Architects/Consultants, where green drivers are similar to barriers in strength, though more in number and the level of implementation of the practice is moderate; iii) Green purchasing for Suppliers, where green drivers are similar to barriers both in number and strength terms and the level of implementation of the practice is low.
- Overall from a practical perspective, green practice implementation can be enabled by working only on the drivers leveraging them, or working only on the barriers and mitigating them, or using an in-between approach of leveraging some drivers and mitigating some barriers; the choice could be based on economic logic and ease of implementation. This can be expected to work both at an individual firm level as well as for the sector as a whole where the extent of implementation of a green practice would be the focus and of interest to policy-makers.

4.6. Relationships between green practices and green performance

The extent of performance improvement (overall) of each green performance dimension from the combined implementation of green practices has been discussed earlier in Section 4.4 and captured in

Table 7. While this understanding is useful for policy makers, industry leaders and top management to assess the overall benefits of green practice implementation, from an operational/ implementation perspective, it would be more useful for managers to know the relevance/contribution of individual green practices on each performance dimension because each green practice impacts each performance differently. From a practical perspective, this understanding is very important especially for firms with resource constraints to prioritize the implementation of those green practices that provide a greater improvement in performance than others. Also, findings can be used to support company decisions to either modify the green practices already in place or to identify new green practices to implement in line with their performance goals/target.

Again, from the interviews, we understood the relevant one to one relationships between individual green practices and each green performance dimension for all stakeholders. Table 9 captures the impact (in strong, moderate and low/no terms) of each green practice on each performance dimension. Each relevance/contribution recording in Table 9 is reflective of both the intrinsic effect of a green practice on a green performance measure as well as the extent of implementation of that practice.

Table 9. Relationships between green practices and green performance

✓✓ Strong contribution ✓Moderate contribution Blank cell: Low/no contribution

	Core green practices						Facilitating green practices					Green-related performance measure (Extent of improvement as per Table VII)
	Environmental impact assessment	Green design	Green purchasing	Green transportation	Green construction/manufacturing*	End-of-life management	Environmental management system (EMS) and ISO 14001	Environmental training	Environmental auditing	Cross-functional integration	Green-related R&D	
Developer	✓	✓✓	✓				✓✓		✓	✓		Environmental performance (High)
												Economic/cost performance (Nil/low)
	✓	✓✓	✓			✓	✓	✓	✓			Organizational performance (High)
Architect/ Consultant												Environmental performance (Not measured)
												Economic/cost performance (Not measured)
	✓	✓✓				✓	✓✓	✓	✓		✓	Organizational performance (High)
Main/Sub-Contractor			✓	✓	✓✓	✓	✓	✓	✓	✓		Environmental performance (Moderate)
				✓	✓✓	✓	✓	✓	✓	✓		Economic/cost performance (Moderate)
			✓	✓	✓✓	✓	✓	✓	✓			Organizational performance (Moderate)
Supplier	✓				✓✓		✓✓		✓	✓		Environmental performance (High)
					✓✓		✓✓		✓			Economic/cost performance (High)
	✓				✓✓		✓✓	✓	✓		✓	Organizational performance (High)

Green construction for Main/Sub-Contractor and green manufacturing for Supplier

Some of the key aspects apparent from the table include:

- For any stakeholder, for any of environmental or cost/economic or organizational performance measures, we can identify green practices that cause the largest improvement in performance, as well as those practices whose contribution to performance improvement is minimal. Managers, depending on their performance focus, can use this information to prioritize green practice implementation; where the focus is on improving performance in all three measures, prioritization of green practices would need to be from that perspective, i.e. considering each green practice's contribution to performance improvement on all three performance dimensions.
- Some green practices, such as EMS and ISO14001 and environmental auditing, not only improve performance on all three green performance measures, they do so for all the stakeholders. Being able to identify green practices of this kind, which have a sector-wide positive influence on performance, would be of interest to policy makers. It will help them focus their efforts on mechanisms/incentives, which can enhance the implementation of such green practices.
- The finding shows there exist significant "win-win" opportunities for firms that seek to implement green practices in the construction sector.

5. Conclusions

The study overcomes the sector's fragmented approach to greening by conducting a holistic GSCM investigation. Even though the findings of this study may vary by country, given the fact that most of the underlying issues in construction are similar in most countries, the insights obtained from this study, can be used as a good starting point for practitioners and policymakers in other countries to minimize the negative environmental impacts of the sector.

In terms of practical implications, the study provides practitioners and policymakers associated with the construction sector insights into the various green practices and their extent of implementation across all key supply chain stakeholders. Also, the understanding gained on the perceived strength/relevance on the drivers and barriers of green practices across stakeholders in the UAE as well as its impact on individual green practices would be useful for practitioners and policy makers to focus on the right drivers that provide maximum leverage and barriers for mitigation. Further, the study contributes to a better understanding of the importance of performance measurement and the use of performance measures to assess the overall performance improvement from green practice implementation across all three performance dimensions. In addition, the understanding on the links between individual green practices and each performance aspects (environmental, cost/economic and organizational) is useful for operational/implementation managers to prioritize implementation of those practices vis-à-vis performance in line with their performance goals. From a sectoral/country level, the study provides useful insights for policy makers and industry leaders to come up with the right policies and support systems for improving the greening efforts of all key stakeholders, especially those who are lagging others.

Overall, the case of UAE is encouraging for the sector in general, as the implementation of green practices, has improved not only environmental performance but also generated substantial cost savings

and improved organizational performance such as enhanced sales revenue, market share, profits, and returns on investments. These findings show that "being green pays" both in the short run and in the long run, and should therefore substantially encourage firms who are doubtful about the benefits of green practices.

In terms of research implications, the study fills a gap in the literature with regards to the application of GSCM in the construction sector. Given the fact that no previous studies have looked at systematically greening the construction sector in such detail, the findings of this study are both novel and significant. The multifaceted nature of the investigation means that future researchers and practitioners can adapt and apply the GSCM approach undertaken in this study to construction and other sectors elsewhere.

However, the qualitative assessment of this research was based on only 31 interviews. Therefore, the empirical generalizations drawn are indicative rather than conclusive, and the qualitative assessment of the relationships is more intuitive than statistically based. However, despite this limitation, the findings serve as a good starting point for enhancing the greening efforts of the construction sector. Future researchers could use empirical survey-based research on a larger scale to test and validate the findings of this study. Future researchers could also investigate the moderating role of size and ownership on each of the green drivers, barriers, practices and performance and in their relationships. For instance, which practices are more adopted as per the size of the organization? Which practices are predominantly accepted in local, foreign and joint venture organization? Such findings could provide further insights towards greening the construction sector.

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Appendix 1. Interview Protocol

- What are the green practices implemented by your firm?
- To what extent do you implement these green practices?
- Why do you implement some green practices more than others?
- What external factors drives your firm in implementing these green practices?
- How do you rate the importance/strength of these external pressures in terms of their ability in driving green practices?
- What factors drives your firm internally in implementing these green practices?
- How do you rate the importance/strength of these internal pressures/motives in terms of their ability in driving green practices?
- Does your firm use any environmental performance measures to assess the benefits of those green practices implemented in your firm? If so, why these measures? (if not, why not use measures?)
- In your opinion, what are the important environmental performance measures to assess the benefits of green practices? Why do you select these measures?
- Do you see any overall improvement in environmental performance, a while after the implementation of green practices? If so, to what extent and why? (If not why?)
- Does your firm use any cost/economic performance measures to assess the overall cost implications of those green practices implemented in your firm? If so, why these measures? (if not, why not use measures?)
- In your opinion, what are the important cost/economic performance measures to assess the cost implications of green practices? Why do you select these measures?
- Do you see any improvement in cost/economic performance, a while after the implementation of green practices? If so, to what extent and why? (If not why?)
- Does your firm use any organizational performance measures to assess the overall long term benefits of those green practices implemented in your firm? If so, why these measures? (if not, why not use measures?)
- In your opinion, what are the important organizational performance measures to assess the long-term benefits of green practices? Why do you select these measures?

- Do you see or foresee any long-term improvement in organizational performance after the implementation of green practices? If so, to what extent and why? (If not why?)
- Could you highlight the one to one impact (in terms of strength) of those external and internal drivers mentioned by you on those specific green practices implemented by your firm? (eg: to what extent the government regulations impact your green design)
- Similarly, could you highlight the one to one impact (in terms of strength) of those external and internal barriers mentioned by you on those specific green practices implemented by your firm? (eg: to what extent the lack of green suppliers impact your green design)
- Could you highlight the one to one impact (in terms of strength) of those specific green practices implemented by your firm on environmental, cost/economic and organizational performance? (eg: to what extent the green design practices improved your environmental performance)

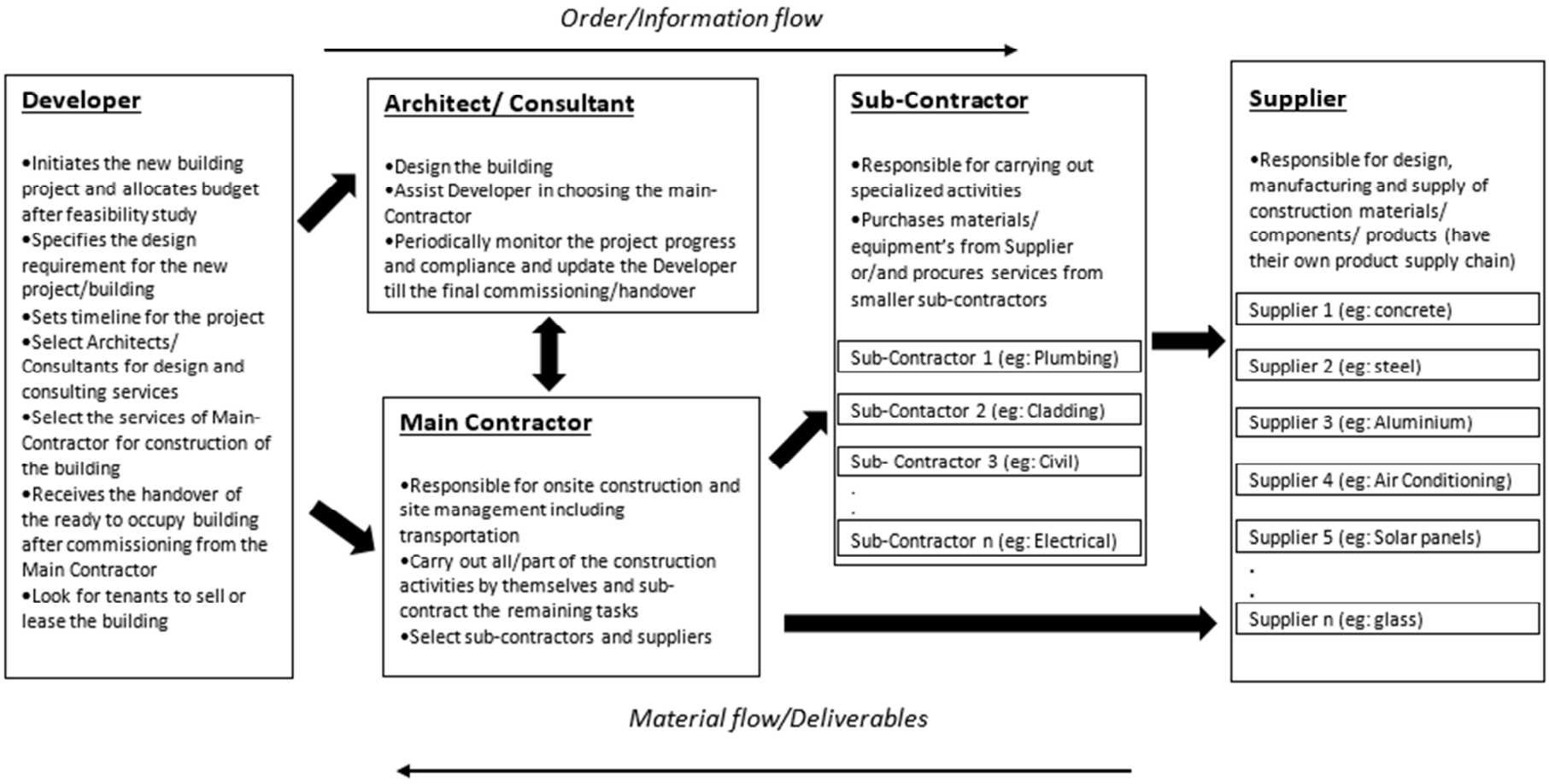

Figure 1. Construction Supply Chain

Green Supply Chain Management: The Case of the Construction Sector in the United Arab Emirates (UAE)

*Sreejith Balasubramanian[a] and Vinaya Shukla[b]

[a]*Department of Business, Middlesex University, Dubai, United Arab Emirates and Business School, Middlesex University, London, UK*

[b]*Business School, Middlesex University, London, UK*

Mr Sreejith Balasubramanian (Corresponding Author)

Department of Business

Middlesex University Dubai

Knowledge Park, Dubai, UAE

Tel: +971 (0) 4 4 367 8100

Email: s.balasubramanian@mdx.ac.ae

Other Authors:

Dr Vinaya Shukla

Business School

Middlesex University Business School

The Burroughs, London NW4 4BT

Tel: +44(0)20 8411 6075

Email: v.shukla@mdx.ac.uk

Table 1. Summary of GSCM-related studies in the construction sector

Study	Country	Methodology	Primary Focus	Stakeholder; their Characteristics*	Key Findings
Ofori (2000)	Singapore	Literature review	Greening of the supply chain	-	**Green purchasing practices:** Purchase of recyclable products and those with non-toxic ingredients, supplier training on environmental practices, supplier implementation of environmental management systems including ISO 14000 and supplier environmental audit
Ofori et al. (2000) Ofori et al. (2002)	Singapore	Survey	Environmental Management system (EMS) and ISO 14001	Developer, Consultant and Contractor	**Drivers of EMS and ISO 14001:** Mandatory government environmental requirements, client demands, end-purchasers demand for environmental-friendly buildings, pressure of competitors who have implemented similar systems, non-government environmental group campaigns, reducing material wastage, enhancing company's public image, reducing costs and environment protection **Barriers to EMS and ISO 14001:** High implementation cost, recovery of related investments, lack of government support, lack of knowledge, shortage of qualified personnel
Shen and Tam (2002)	Hong Kong	Survey	Environmental Management system (EMS)	Contractor	**Drivers of EMS:** Reduction in environment related fines and associated savings, improvement in corporate image, environment protection **Barriers to EMS:** Lack of government enforcement, increase in costs, lack of trained staff and expertise
Tam et al. (2006)	Hong Kong	Survey and interviews	Environmental performance	Developer, Consultant, Main/Sub-contractor, Large, Medium and Small firms	**Environmental performance measures:** Reduction in energy, material and water consumption
Adetunji et al. (2008)	UK	Case study	Sustainability in supply chains	-	**Drivers of sustainable practices:** Government regulations and associated fines, client requirements, top management commitment, reduction in total project costs, improvement in reputation and image, organizational vision on sustainability **Barriers to sustainable practices:** High implementation cost **Sustainable practices:** Implementation of EMS and ISO 14001, setting environment related pre-qualification criteria for suppliers, environmental training for in-house staff and suppliers, purchasing/using materials that cause less environmental damage and have higher recycled content **Environmental benefits**: Reduction in polluting emissions, environmental accidents and energy consumption, waste minimization, water conservation **Economic benefits:** Lower project costs
Jaillon et al. (2009)	Hong Kong	Survey	Pre-fabrication	-	**Barriers to pre-fabrication:** Higher cost per unit floor area in comparison to traditional approaches, lack of skilled labour **Environmental benefits**: Reduction in construction waste **Economic benefits**: Reduction in construction time and onsite labour requirement
Pitt et al. (2009)	UK	Survey	Sustainable practices	Developer, Architect, Contractor	**Drivers of sustainable practices**: Client demand, government regulations, financial benefits **Barriers to sustainable practices**: Lack of affordability, lack of awareness
Robin and Poon (2009)	Hong Kong	Survey	Cultural Shift in Sustainability	Developer, Architect/Consultant, Contractor and Supplier	Cultural shift in sustainable culture in terms of awareness, concern, motivation and implementation
Varnas et al. (2009)	Sweden	Survey and interviews	Green Purchasing	Developer	**Green purchasing practices:** Environmental criteria at the design stage, requirement to have an environmental and waste disposal plan, to use energy efficient onsite machinery and to use less environmentally harmful materials

*Blanks mean that specific Stakeholder/s and their characteristics are not considered in those studies

Table 1. (continued)

Study	Country	Methodology	Primary Focus	Stakeholder; their Characteristics*	Key Findings
Gangolells et al. (2009)	Spain	Focus group and case study	Environmental impact measures	-	**Environmental impact measures:** Greenhouse gas emissions, water consumption, waste reduction, material consumption, energy consumption, environmental accidents
Chen et al. (2010)	US	Survey	Sustainability measures	Developer, Architect, Contractor, Supplier	**Environmental performance measures:** Reduction in air emissions, material consumption, energy consumption and water consumption, reduction in waste generated. **Economic performance measures**: Reduction in material and waste disposal costs
Abidin (2010)	Malaysia	Survey	Awareness about sustainable construction	Developer, Small, Medium and Large firms	Environmental aspects of sustainability: High awareness Economic aspects of sustainability: Low awareness
Fernández-Sánchez and Rodríguez-López (2010)	Spain	Literature review and case study	Sustainability indicators	-	**Environmental Indicators:** Water consumption, air emission, material consumption, energy consumption and waste management **Economic Indicators**: Reduction in cost
Qi et al. (2010)	China	Survey	Drivers of green practices	Contactor, Small, Medium and Large firms	**Drivers of green practices:** Government environmental regulations, top management commitment, client pressure, pressure from environmental non-government organizations
Sourani and Sohail (2011)	UK	Interviews	Barriers to green purchasing	-	**Barriers to green purchasing:** Lack of funding and high capital cost, lack of awareness and knowledge, lack of long term partnership and lack of government incentives
Zhang et al. (2011)	China	Survey	Barriers to green practices	-	**Barriers to green practices:** Higher costs of implementation, lack of knowledge and awareness, lack of clarity in tender specification and conflict of stakeholder interests
Liu et al. (2012)	China	Survey	Drives and barriers to green practices	-	**Drivers of green practices**: Support/incentives from government and to gain reputation **Barriers to green practices**: Lack of green building professionals, high cost of implementation and lack of green construction knowledge **Green design practices:** Selection of sustainable sites, consideration in design to reduce material usage, use more environmental friendly materials and have more natural luminance and ventilation as well as provision for water reduction and recycling
Ng et al. (2012)	Generic	Literature review	Carbon dioxide reduction strategies across the lifecycle of a Building	-	**Carbon reduction in planning and design:** Natural ventilation, natural lighting, renewable energy integration, low energy lighting and low energy cooling and heating systems **Carbon reduction during material selection and construction:** Selection of materials with low embodied energy and high re-cycled content, use of fuel efficient machinery (onsite) and prefabricated materials (offsite) **Carbon reduction during end of life demolition:** Recycling and reuse of material
Carris et al. (2012)	UK	Case study	Sustainability in supply chain	-	**Drivers of sustainable supply chain:** Enhancing reputation, client requirements, regulation/legislation, corporate sustainability objectives, cost reduction **Barriers to sustainable supply chain:** Lack of awareness and knowledge, high cost of research and development for implementing sustainable practices
Akadiri and Fadiya (2013)	UK	Survey	Drivers of environmental practices	Small, Medium and Large firms	**Drivers of environmental practices:** Government regulation, pressure from clients, pressure from environmental non-government organizations, top management commitment towards environment and improving company image
Shi et al. (2013)	China	Survey	Barriers to green construction	Developer, Consultant and Contractor	**Barriers to green construction**: Additional costs for green construction, lack of awareness and knowledge, and lack of green suppliers
Zutshi and Creed (2014)	Generic	Literature review	Environmental Management System (EMS)	-	**Barriers to EMS**: High cost of implementation, lack of stakeholder co-operation, lack of trained staff and expertise, long registration process for ISO 14001 certification **Economic benefits**: Lower material and energy costs and reduction in environment related fines

*Blanks mean that specific Stakeholder/s and their characteristics are not considered in those studies

Table 2. Key Informants for interviews

Stakeholder	Size	Annual Revenues	Majority Ownership	Interviewee/s
Developer 1	Small	~$500 million	Local	Environmental Analyst, Manager (Community Development)
Developer 2	Medium	~$900 million	Local	Environmental Manager, Manager (Waste), Head of Projects
Developer 3	Large	~$2 billion	Local	Senior Manager (Planning & Sustainability)
Architect/Consultant 1	Small	~$30 million	Foreign	Sustainability Specialist, Senior Architect
Architect/Consultant 2	Medium	~$150 million	Foreign	Head of Sustainability
Architect/Consultant 3	Large	~$600 million	Foreign	Senior Consultant
Architect/Consultant 4	Small	~$50 million	Local	Consultant (Environment and Sustainability)
Architect/Consultant 5	Medium	~$200 million	Local	Senior LEED Consultant
Architect/Consultant 6	Large	~$500 million	Local	Director (Projects)
Main contractor/subcontractor 1	Small	~$90 million	Local	General Manager
Main contractor/subcontractor 2	Medium	~$450 million	Local	Senior Project Manager
Main contractor/subcontractor 3	Large	~$800 million	Local	Senior Manager (Tender), Manager (Business Development)
Main contractor/subcontractor 4	Small	~$75 million	Foreign	Technical Manager
Main contractor/subcontractor 5	Medium	~$300 million	Foreign	Project Manager
Main contractor/subcontractor 6	Large	~$550 million	Foreign	Sustainability Manager, Purchase Manager
Supplier 1 (Cement)	Small	~$20 million	Local	Senior Manager (HSE)
Supplier 2 (Steel)	Medium	~$125 million	Local	Production Head
Supplier 3 (Aluminum)	Large	~$2.3 billion	Local	Procurement Manager, Head of Quality, Head of Manufacturing, Manager (Quality and Production)
Supplier 4 (Gypsum, Cladding)	Small	~$25 million	Foreign	Production Manager
Supplier 5 (Cement)	Medium	~$150 million	Foreign	Operations Manager
Supplier 6 (Glass)	Large	~$800 million	Foreign	Senior QC Engineer, Head (Product Design)

Note: Very few foreign Developers are operative in UAE (Zawya, 2015), these are therefore not covered

Table 3. Core green practices and their extent of implementation

Core green practice	Developers	Architects/ Consultants	Main/Sub-Contractors	Suppliers
Environmental Impact Assessment	**High** • Done at the project concept stage and by most firms • Potential impact of project on natural habitat (flora & fauna) and air and water pollution assessed	**High** Do the actual assessment (alone or with the Developer)	**Not Relevant** *No involvement with projects at this stage*	**Moderate** Potential impact of project on noise levels, air quality and water sources assessed; mostly done by large firms & foreign firms
Green design	**High** • Emphasised in government regulations, LEED/ BREEAM certifications; practices applied vary across projects • Aspects considered: Natural lighting and ventilation, use of water saving technologies, use of green materials, reduced use of hazardous materials and energy consumption based designing • Additional aspects considered by large firms incl. use of photo-voltaic panels & more recyclable materials (to increase recovery at end of life), modular design (for ease of disassembly), pre-fabrication & waste water recycling	**High** • Actually develop the designs incl. green related as required by the Developer • Better capabilities at foreign firms; are able to access the centrally (at HQ) available tools and expertise	**Not Relevant** *No involvement in design incl. green-related; enter after finalisation of design which they have little authority to change*	**Low** • Relevant aspect is (green) material design • Green material offering is standard rather than customised to individual customer/project requirements; green material sales constitute only a small proportion of total sales
Green purchasing	**Moderate** Essentially in relation to purchase of services (materials purchase is typically by Contractors), which are purchased from Architects/Consultants & Contractors, in whose selection, green-related criteria are applied as below: • At pre-qualification stage: LEED certified staff in rolls + track record on LEED projects (for Architects/ Consultants) and EMS and ISO14000 certification (for Contractors) • At selection stage: 10-30% weight to green consideration in design (for Architects/Consultants) and to environment & waste management plan (for Contractors); Small firms ~10% weightage, large ones ~ 30% weightage	**Not Relevant** *No direct involvement in purchasing*	**Moderate** • Is in relation to materials & service purchases from Suppliers & Sub-Contractors respectively • Smaller firms: purchase of green materials is entirely as per the contractual requirements (of the Developer) • Large local and all foreign firms: exceed Developer's contract requirements such as on green material specifications, auditing suppliers (for green), considering LEED experience & no. of LEED certified staff in rolls for sub-contractor selection as well as making EMS and ISO 14001 mandatory for them	**Low** The green input material purchase is as per the green material demand, which constitutes only a small part of the total material demand.
Green transportation	**Low** No significant consideration from both material as well as employee (transportation) perspectives, and at own as well as downstream stakeholders	**Low** Local firms: No significant consideration; Foreign firms: Use video conferencing to minimize employee travel and thereby emissions	**High** • Preference for full truck load transportation, use of fuel efficient vehicles and employee accommodation near project sites • Large local and all foreign firms: additional practices such as choosing geographically closer suppliers (less material travel) and scheduling material deliveries during periods of less traffic congestion (lower fuel consumption, lesser emissions)	**Moderate** • Full truck-load transportation to minimise emissions is common • Use of other emission control practices varies; these incl. choosing geographically closer suppliers, choosing low-emitting transport modes, considering traffic congestion when planning deliveries, locating employees near manufacturing sites and sharing transportation
Green Construction/ Manufacturing	**Not Relevant**	**Not Relevant**	**High** • Automated (and therefore less waste generating) & energy efficient machinery used • Waste segregated to enable its reuse/recycling • Pre-fabrication used (to reduce onsite waste)	**High** State of the art equipment that consumes less energy, causes less emissions and lower (manual related) wastage/ errors used for manufacturing all materials in most firms
End of Life Management	**Moderate** • No specific regulations for this • Not considered by small firms; large firms consider related design aspects like modular design (for easier disassembly), and use of more recyclable materials (to enable their reuse at end of life), though which varies across projects	**Moderate** Actually develop the relevant end of life designs; Better tools, expertise with foreign firms	**Moderate** • No specific regulations for this • Practices include use of energy efficient demolition equipment, selective dismantling of buildings, segregation of demolition waste and safe disposal of hazardous materials	**Not Relevant**

Table 4. Facilitating green practices and their extent of implementation

Facilitating green practice	Developers	Architects/ Consultants	Main/Sub-Contractors	Suppliers
Environmental Management System (EMS) and ISO 14001	**High** EMS, and which is ISO14001 certified, is implemented at most firms	**High** Most firms have EMS; a sizeable proportion of these also have ISO14001 certification	**Moderate** A good proportion of firms have EMS among which a good proportion have ISO 14001 certification also	**High** EMS and with ISO14001 certification is operational in most firms
Environmental training	**High** At most firms • Dedicated in-house training department which also imparts environmental training • Training provided to both own as well as Contractor's & Supplier's employees At large firms: Longer i.e. ~ months and broader i.e. curriculum based training; At small firms: usually day/ week long training	**High** • Extensive environmental training is provided to employees at most firms; In a significant proportion of firms this training is also provided to Contractor's & Supplier's employees • Most firms are also providing opportunities to their employees to gain LEED /other international certifications	**Moderate** • Training is provided mostly to own employees • At foreign firms the content of training programmes is comprehensive and which is imparted to employees at all levels; At local firms the training is more on waste minimisation practices and is limited to onsite workers	**Moderate** • Training is provided predominantly to own employees • Training is usually on operational aspects of manufacturing such as on improving plant efficiency and reducing waste and pollution
Environmental auditing	**High** Done by most firms and includes both internal as well as external auditing (of other stakeholders)	**High** • Done by most firms • Both ongoing projects as well as suppliers are audited	**Moderate** • Large local and all foreign firms: do both internal as well as external auditing (of suppliers); internal auditing at foreign firms is more stringent in line with the firm's global/ headquarter requirements • Small and medium local firms: do only internal auditing	**Moderate** Mostly limited to internal auditing
Cross-functional integration	**High** • At most firms, cross-functional teams from sales, purchase and environmental departments work together from project conceptualisation to completion and handover • Cross-functional teams ensure good cooperation between their respective departments; enable realisation of the firm's environmental vision and mission	**Moderate** Significant difference between local and foreign firms • Foreign firms: Emphasis on cross-functional teams both within the firm and with head office; organisation structure (decentralised) and culture both support formation of teams • Local firms: No/limited use of cross-functional teams	**Moderate** Significant difference between local and foreign firms • Foreign firms: Significant use of cross-functional teams; supportive structure and culture • Local firms: Limited cross- functional integration; hierarchical organisation structure is a hindrance	**High** • Cross functional teams from sales, purchase, operations, manufacturing, research and development and environmental departments used • Teams work together on all green-related projects
Green-related Research and Development (R&D)	**Low** Limited emphasis with no dedicated budget; prefer getting best practices from other countries	**Moderate** • Foreign firms have a large budget with many researchers working on green design techniques and solutions • No dedicated budget and limited effort at local firms	**Low** Limited emphasis with no dedicated budget; favour getting best practices from developed countries instead	**High** • Significant emphasis in most firms in anticipation of future potential (of green materials) • Contributes significantly towards developing innovative materials

Table 5. Green drivers and their relevance/strength perceived by stakeholders

External Drivers	Developers	Architects/Consultants	Main/Sub-Contractors	Suppliers
Government regulations	**High** • Stringent regulatory pressure (Dubai Green Building Regulation, ESTIDAMA in Abu Dhabi, EHS Trakhees in Free Zones) • Strict enforcement and stringent fines for non-compliance	**Low** No regulations	**High** Stringent regulations, which require: • At least 50% of the waste generated to be recycled/reused (instead of being landfilled) • Environmental management system (mandatory) • A construction and waste management plan (CWMP) as per prescribed format in advance of operations commencement	**Low** No regulations
Stakeholder pressure	**Low** Other stakeholders have little influence	**High** Pressure essentially from Developers who: • Require support to meet the green regulatory or LEED/ BREEAM certification requirements • Assess green-related expertise and experience when awarding contracts		**Moderate** • Pressure from Consultant and Contractor to meet green material requirements • Pressure from Contractor to sign the UN Global compact (to demonstrate sustainability) and to install EMS
Competitor pressure	**High** Increasing trend among firms to develop LEED/BREEAM certified projects	**High** Increasing influx of foreign firms with advanced green knowledge and capabilities		**Low** Few firm's operatives in the country; competition in general is low
Consumer pressure	**Low** • Consumer has limited awareness and appreciation of green (projects) • Consumer lacks affordability	**Not Relevant** *No direct interaction with consumers*		
Internal Drivers				
Environmental commitment	**High** Most firms have: • A comprehensive corporate environmental policy • Good top, middle and operational management support for green	**Moderate** • High for foreign and large local firms: on account of (comprehensive and stringent) environmental policy at HQ; to lower risks to reputation from environmental accidents • Low for small/ medium size local firms: Less focus on environmental aspects and more on economic returns		**High** A significant proportion of firms have: • Sustainability in their vision and mission statements • A carbon mgmt. strategy with targets • A sustainability report published annually
Enhance reputation/brand image	**High** • To be attractive to foreign investors • To improve relationship with government construction bodies • To sell projects faster; to sell projects at a premium, if possible	**Moderate** • High for all foreign and large local firms: So as to win projects from environmentally reputable Developers; to be able to charge a premium • Low for small and medium sized local firms		**High** • To be able to increase exports • To convince Consultants to include their materials in the tender specification • To charge a premium
Cost savings	**Not Relevant** No direct cost savings		**High** Reduction in onsite construction costs, specifically material, labour, transportation & landfill costs; shorter project completion times also with some practices (e.g. pre-fabrication)	**High** Significantly lower energy, water and waste processing costs with green manufacturing
Enter foreign markets	**High** • Green-related regulations of foreign markets need to be met • Green credentials like LEED gold/ platinum certification necessary for impressing foreign clients/investors	**Moderate** •High for foreign firms; participate in neighbouring countries' tenders using UAE as the base • Low for local firms; UAE focussed	**Moderate** • High for all foreign and large local firms; participate extensively in global tenders • Low for small and medium sized local firms; mostly UAE focussed	**High** Materials need to have green attributes for successful exports

Table 6. Green barriers and their relevance/strength perceived by stakeholders

	Developers	Architects/Consultants	Main/Sub-Contractors	Suppliers
External Barriers				
Shortage of green professionals	**High** • Local universities, colleges and training centres offer few courses on green/sustainable architecture and construction • Opportunities provided by the government for professionals to acquire green certification has had only a limited success			**Low** Greening is equipment/technology dependent (on which staff are trained in-house) & (green) input materials
Shortage of local green material suppliers	**High** • Project costs are higher as green material has to be imported, which, on account of the transportation involved, is more expensive • Project delay risks are higher due to uncertainties associated with imports (of green material that are required) • Project green /environmental objective is compromised: the transportation associated with green material imports (that are required) mean more emissions	**Moderate** Design changes have to be made to cope with project cost and time escalation caused by the uncertainties associated with green material imports (that are required)	**Moderate** • High for local firms: Have to establish relationships and get good credit terms from foreign suppliers which is challenging; also, causes green materials to be imported thereby making them more expensive and delay prone (due to the transportation involved) • Low for foreign firms: Are able to tap into their global level arrangements with green material supplier firms to get competitive prices, good credit and delivery terms & with less risk of delays	**Low** Adequate green input material supplies are locally available
Tight and inflexible stakeholder deadlines	**Low** • Have control over how green & speed (or deadlines) are to be balanced though: 1) Demand for buildings in UAE is outstripping supply necessitating faster completions, 2) Green building planning & preparation takes more time than a conventional building	**High** • The deadlines in line with the quick project completion requirements come from the Developer and which are enforced with penalties • Green building design takes more time than a conventional one (for Architects/ Consultants); similarly, for Contractors, site preparation, waste management and other green practices take (additional) time. With tight and inflexible deadlines therefore, green practices tend to get compromised		**Low** The green materials produced/ supplied are generally standard rather than customised
Lack of stakeholder collaboration	**Low** Have control over the nature and extent of collaboration with (downstream) stakeholders	**Moderate** Trust deficit with Developers (the relevant stakeholder) due to: • Project awards by them being one-off rather than in a long-term relationship mode • Non-sharing of green-related knowledge by them due to fear that it could be leaked to competitors Green designing effectiveness is compromised as a result	**High** • Trust deficit with Developers due to project awards by them being one-off rather than in a long-term relationship mode; causes misunderstanding and lack of flexibility on green related responsibilities and solutions • Trust deficit with Architects/Consultants; they do not provide complete information on important aspects such as constructability & environmental impact due to fear that their role could be taken over in future; green-construction-related planning is made more difficult as a result	**Low** Generally standard green materials produced and supplied; collaboration is not therefore considered critical
Internal Barriers				
Lack of knowledge and awareness of green practices	**Moderate** • Overall knowledge is reasonable; needed to appreciate regulations & competitor actions • Knowledge of environmental performance measurement/ monitoring though is limited	**Low** Almost all firms have LEED certified employees in their rolls	**Moderate** In most firms, good knowledge and awareness at the corporate level; at the project manager level though, the knowledge varies & adversely affects onsite green practices application where low	**Low** Knowledge is kept up-to-date (through training programs) to facilitate research & development of new green materials
High cost of implementation	**High** Green projects significantly more expensive than conventional ones: (green) material costs and architectural and consulting fees are higher; there are additional costs (of equipment's such as recycling systems & solar panels and of LEED /BREEAM certification)	**Moderate** • High for local firms; low for foreign firms (able to use HQ or centrally available resources) • Key costs: cost of green design software, EMS & ISO 14001 and of LEED/ BREEAM professionals	**Moderate** • Low for all foreign & large local firms as this cost is only a small proportion of their total costs; foreign firms also leverage global knowledge base and tie-ups; high for small & medium sized local firms • Key costs: Automated equipment (concrete mixers, spreaders) to reduce onsite waste, EMS& ISO14001	**High** • Green materials manufacturing equipment/tech. is expensive • Green input materials are more expensive than conventional ones • Significant R&D investments needed to develop green materials

Table 7. Green performance (measures and extent of improvement)

		Developers	Architects/ Consultants	Main/Sub-Contractors	Suppliers
Environmental Performance	**Sub-measures used**	Energy and water consumption and number of environmental accidents used at most firms and as required by regulations; additional measures for LEED/BREEAM projects as per the respective certification requirements	Water and energy consumption and quantity of air emissions (that are estimated) used, but only for a few most environmentally friendly projects	• Amount of air emissions, use of hazardous materials, material, energy and water consumption, waste landfilled and number of environmental accidents used at large local and all foreign firms, though with the exact measures being different • Waste generated & landfilled and number of environmental accidents used at small and medium sized local firms (regulatory reqmt.)	Amount of air emissions, use of hazardous materials, material, energy and water consumption, waste landfilled and number of environmental accidents used at most firms
	Extent of improvement from green practices	**High** Lower water and energy consumption and fewer environmental accidents at most firms; used in subsequent sales pitches to prospects	Improvements in the above assessed once (after a few months of project completion) based on data provided by Developers; used in subsequent sales pitches	**Moderate** • Overall improvement for large local and all foreign firms with more improvement for the latter • No improvement at small and medium sized local firms	**High** Overall improvement at most firms
Economic/Cost Performance	**Sub-measures used**	Material cost and amount of environmental fines used at most firms	At most firms, no separate measures or monitoring of green projects	• Material cost, energy and water cost, waste treatment cost and environmental fine amount used at large local and all foreign firms, though with the exact measures being different • No measures used at small and medium sized local firms	Material cost, energy and water cost, waste treatment cost and environmental fine amount used at most firms
	Extent of improvement from green practices	**Nil/Low** For many firms: • Material cost is higher; higher unit cost (for green materials) dominates reduced material requirement (from green practices) • No significant impact on amount of environmental fines; already quite low having been reduced over time		**Moderate** • Lower cost in overall terms for large local and all foreign firms and particularly lower for the latter • No change in overall cost for small and medium sized local firms	**High** All the above costs are lower for most firms except material cost (which is higher)
Organizational Performance	**Sub-measures used**	Sales, market share, profit and return on investment used at most firms	Number of projects awarded, market share and profits, which are used at most firms	Number of projects awarded, market share, profits and return on investments, which are used at most firms	Sales, market share, profits and return on investments, which are used at most firms
	Extent of improvement from green practices	**High** For most firms: • More (project) sales and gain in market share • No significant improvement in profits; premium on green buildings difficult to get & which barely recovers the additional costs incurred • Significant improvement in return on investment (due to reduced cost of capital on account of firm's enhanced rating and attractiveness)	**High** For most firms: • Increase in the number of projects awarded • Gain in market share • More profits (higher fee realisation more than compensating for higher costs) • Higher return on investment which is only in perception terms as not formally measured	**Moderate** • For most foreign firms: More projects awarded, gain in market share and profits, the last through higher fee realisation for green projects and lower costs from onsite green practices and despite the higher costs of (green-related) equipment; the return of investment is also higher • Lower performance (in relation to foreign firms) in each measure for large local firms; even lower performance for small and medium sized local firms	**High** For most firms: • More sales and gain in market share • More profits from premium pricing and lower (green) manufacturing costs, though partly offset by higher input (green) material costs & the higher cost of (green) equipment • Higher return on investment, but only moderately so, due to the significant investments made on green manufacturing equipment and green-related R&D

Table 8. Relationships between green drivers, green barriers and green practices

✓✓ High strength ✓ Moderate strength Blank cell: Low/negligible

strength

	External Drivers			Internal Drivers				External Barriers				Int. Barriers		
	Government Regulations	Stakeholder pressure	Competitor Pressure	Environmental Commitment	Enhance reputation/Brand	Cost savings	Enter foreign markets	Shortage of green professionals	Shortage of local green material suppliers	Tight and inflexible stakeholder deadlines	Lack of stakeholder collaboration	Lack of knowledge and awareness of green practices	High cost of implementation	**Green Practice (Extent of application as per Table 3 and 4)**
Developer			✓	✓	✓		✓	✓				✓	✓	Env. impact assessment (High)
	✓✓		✓✓	✓	✓✓		✓	✓	✓				✓✓	Green design (High)
	✓		✓	✓✓	✓		✓	✓				✓	✓	Green purchasing (Moderate)
												✓✓		Green transportation (Low)
			✓	✓	✓		✓	✓				✓	✓	End of life management (Moderate)
			✓✓	✓✓	✓✓		✓✓	✓				✓	✓	EMS & ISO 14001 (High)
			✓	✓✓	✓			✓				✓	✓	Environmental training (High)
			✓	✓✓	✓			✓				✓	✓	Environmental auditing (High)
				✓✓	✓									Cross-functional Integration (High)
								✓✓				✓✓		Green-related R&D (Low)
Architect/ Consultant		✓✓			✓		✓	✓		✓	✓			Env. impact assessment (High)
		✓✓	✓✓	✓	✓✓		✓✓	✓	✓	✓✓	✓		✓	Green design (High)
				✓										Green transportation (Low)
		✓✓	✓		✓		✓	✓		✓	✓			End of life management (Moderate)
		✓✓	✓✓	✓✓	✓✓		✓✓	✓					✓	EMS & ISO 14001 (High)
		✓	✓	✓	✓		✓	✓			✓		✓	Environmental training (High)
		✓	✓	✓	✓		✓	✓			✓		✓	Environmental auditing (High)
			✓	✓										Cross-funtl. Integration (Moderate)
			✓	✓	✓		✓	✓			✓		✓	Green-related R&D (Moderate)
Main/Sub-Contractor		✓✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	Green purchasing (Moderate)
				✓✓	✓	✓						✓✓	✓	Green transportation (High)
	✓✓	✓✓	✓	✓	✓	✓✓	✓	✓✓		✓	✓	✓	✓	Green construction (High)
		✓	✓	✓	✓			✓		✓✓	✓	✓		End of life management (Moderate)
	✓✓	✓✓	✓	✓	✓		✓	✓				✓	✓✓	EMS & ISO 14001 (Moderate)
		✓	✓	✓	✓		✓	✓				✓	✓	Environmental training (Moderate)
		✓	✓	✓	✓		✓					✓	✓	Environmental auditing (Moderate)
				✓		✓						✓		Cross-funtl. Integration (Moderate)
												✓	✓	Green-related R&D (Low)
Supplier				✓	✓								✓	Env. Impact assessment (Moderate)
		✓		✓	✓		✓						✓	Green (material) design (Low)
				✓									✓	Green purchasing (Low)
				✓	✓									Green transportation (Moderate)
				✓✓	✓✓	✓✓	✓✓						✓✓	Green manufacturing (High)
		✓✓		✓✓	✓✓		✓✓						✓	EMS & ISO 14001 (High)
				✓	✓		✓						✓	Environmental training (Moderate)
				✓	✓		✓						✓	Environmental auditing (Moderate)
				✓✓	✓									Cross-functional Integration (High)
				✓	✓✓		✓✓						✓✓	Green-related R&D (High)

Table 9. Relationships between green practices and green performance

✓✓ Strong contribution ✓Moderate contribution Blank cell: Low/no contribution

	Core green practices						Facilitating green practices					Green-related performance measure (Extent of improvement as per Table 7)
	Environmental impact assessment	Green design	Green purchasing	Green transportation	Green construction/manufacturing*	End-of-life management	Environmental management system (EMS) and ISO 14001	Environmental training	Environmental auditing	Cross-functional integration	Green-related R&D	
Developer	✓	✓✓	✓				✓✓		✓	✓		Environmental performance (High)
												Economic/cost performance (Nil/low)
	✓	✓✓	✓			✓	✓	✓	✓			Organisational performance (High)
Architect/ Consultant												Environmental performance (Not measured)
												Economic/cost performance (Not measured)
	✓	✓✓				✓	✓✓	✓	✓		✓	Organisational performance (High)
Main/Sub-Contractor			✓	✓	✓✓	✓	✓	✓	✓	✓		Environmental performance (Moderate)
				✓	✓✓	✓	✓	✓	✓	✓		Economic/cost performance (Moderate)
			✓	✓	✓✓	✓	✓	✓	✓			Organisational performance (Moderate)
Supplier	✓				✓✓		✓✓		✓	✓		Environmental performance (High)
					✓✓		✓✓		✓			Economic/cost performance (High)
	✓				✓✓		✓✓	✓	✓		✓	Organisational performance (High)

**Green construction for Main/Sub-Contractor and green manufacturing for Supplier*