Sustainability In Construction In The UAE

الأمارات في البناء في الاستدامة

by

AHMED TAHA AL FAHIM

Dissertation submitted in fulfilment

of the requirements for the degree of

MSc PROJECT MANAGEMENT

at

The British University in Dubai

November 2020

DECLARATION

I warrant that the content of this research is the direct result of my own work and that any use made in it of published or unpublished copyright material falls within the limits permitted by international copyright conventions.

I understand that a copy of my research will be deposited in the University Library for permanent retention.

I hereby agree that the material mentioned above for which I am author and copyright holder may be copied and distributed by The British University in Dubai for the purposes of research, private study or education and that The British University in Dubai may recover from purchasers the costs incurred in such copying and distribution, where appropriate.

I understand that The British University in Dubai may make a digital copy available in the institutional repository.

I understand that I may apply to the University to retain the right to withhold or to restrict access to my thesis for a period which shall not normally exceed four calendar years from the congregation at which the degree is conferred, the length of the period to be specified in the application, together with the precise reasons for making that application.

_____

Signature of the student

COPYRIGHT AND INFORMATION TO USERS

Abstract

The realization of the construction projects is dependent on the successful realization of a large set of criteria. Among them, the key role is played by the following parameters: budget and schedule requirements to the project, quality characteristics, and security of potential stakeholders that will utilize the construction facility in the future. Due to the definition of the rising role of sustainability in operations of the business, the criteria of sustainability were also identified as an important requirement for the construction project in different countries, including the UAE. In this dissertation, this paper aims to provide a complex and detailed answer to the range of questions in the sphere of sustainable waste management for construction projects in the UAE. The significance of this theme was defined with the rising demand for realization of the construction projects in the country, and the associated increase of risk level for the organizations and stakeholders in the sphere of waste management.

For the aims of the study, the following research questions were addressed: definition of key construction and demolition waste streams in the construction sector of the UAE; assessment of the potential impact of construction waste on the environment in the UAE; definition of the existing rules and legal regulations applied to the organization of sustainable waste management in the UAE; and definition of required and recommended changes to the existing practices in waste management for the UAE construction sector to make it more sustainable. To implement the stated research objectives, the procedure of the study was divided into four key stages - literature review, the quantitative method applied through the survey that was distributed to the sample size of 106 participants, the analysis of the results, and the generation of recommendations.

In the context of the literature review, the following questions were addressed: definition of different types of construction and demolition waste in the UAE construction sector; the disposal of the waste streams; assessment of the potential impact of different types of construction waste on the environment; comparison of types of waste sources that are properly and improperly managed in the UAE; existing rules and regulations applied for waste management segment of the UAE construction sector; specific statistics describing the problem of waste management in the UAE; specific factors that lead to ineffective waste management and recommendations that could be applied to guarantee an improved quality of waste management in the UAE construction sector. The results of the literature review had to contribute to a full understanding of the current situation in the sphere of waste management in the UAE and abroad. Results of the literature review defined the actual level of the issue's significance, key sources of problems, and potential solutions that could be applied for the aims of recommendations development.

A quantitative study of primary data collection from 106 participants had to contribute to the definition of the actual situation from the point of view of employees and management operating in the UAE construction sector. The following groups of stakeholders engaged in the UAE construction sector were applied for the study: developer, contractor, consultant, government, and private sector. According to the results, a major part of the participants was aware of sustainability issues in their sphere of work. The effectiveness of sustainability practices applied in their work was assessed as high by the majority of participants. Among the factors of waste management, respondents considered the factors of cost, productivity, waste reduction, and adequate skills as most important. Participants agreed that both private business and government should pay much more attention to the sphere of waste management in the

construction sector. Among the benefits of effective construction waste management, participants of the study-oriented on the factors of cost reduction, increased productivity, improved health, waste minimization, environmental protection, better life quality, and better use of materials.

Based on the study findings, specific recommendations were developed for the UAE construction sector in general. Following findings are important to mention: the need for companies to work toward recycling of construction waste materials; the need for the government to develop a set of clear and transparent rules for the regulation of waste management procedures; requirement for a business to increase the level of awareness and education of employees on the issues of sustainable waste management; and prioritization of reuse of the construction waste materials. Taken together, these measures should contribute to the transformation of waste management practices in the UAE for higher productivity and effectiveness.

الخلاصة

يعتمد تحقيق مشاريع البناء على التحقيق الناجح لمجموعة كبيرة من المعايير. من بينها ، يتم لعب الدور الرئيسي من خلال المعايير التالية: متطلبات الميزانية والجدول الزمني للمشروع ، وخصائص الجودة ، وأمن أصحاب المصلحة المحتملين الذين سيستفيدون من منشأة البناء في المستقبل. نظرًا لتعريف الدور المتزايد للاستدامة في عمليات الأعمال التجارية ، فقد تم تحديد معايير الاستدامة أيضًا كشرط مهم لمشروع البناء في مختلف البلدان ، بما في ذلك الإمارات العربية المتحدة. يهدف المؤلف في هذه الرسالة إلى تقديم إجابة معقدة ومفصلة لمجموعة من الأسئلة في مجال الإدارة المستدامة للنفايات لمشاريع البناء في الإمارات العربية المتحدة. تم تحديد أهمية هذا الموضوع مع زيادة الطلب على تحقيق مشاريع البناء في الدولة، وما يرتبط بها من زيادة مستوى المخاطر للمنظمات وأصحاب المصلحة في مجال إدارة النفايات.

لأهداف الدراسة ، تمت معالجة الأسئلة البحثية التالية: تعريف مجاري نفايات البناء والهدم الرئيسية في قطاع البناء في دولة الإمارات العربية المتحدة ؛ تقييم الأثر المحتمل لمخلفات البناء على البيئة في دولة الإمارات العربية المتحدة ؛ تحديد القواعد واللوائح القانونية الحالية المطبقة على تنظيم الإدارة المستدامة للنفايات في دولة الإمارات العربية المتحدة ؛ وتعريف التغييرات المطلوبة والموصى بها للممارسات الحالية في إدارة النفايات لقطاع البناء في الإمارات العربية المتحدة لجعلها أكثر استدامة. لتنفيذ أهداف البحث المذكورة، تم تقسيم إجراء الدراسة إلى أربع مراحل رئيسية - مراجعة الأدبيات، والطريقة الكمية المطبقة من خلال المسح الذي تم توزيعه على حجم عينة من 106 مشاركًا ، وتحليل النتائج، وتوليد التوصيات.

في سياق مراجعة الأدبيات ، تم تناول الأسئلة التالية: تعريف أنواع مختلفة من نفايات البناء والهدم في قطاع البناء في دولة الإمارات العربية المتحدة ؛ التخلص من مجاري النفايات ؛ تقييم التأثير المحتمل لأنواع مختلفة من نفايات البناء على البيئة ؛ مقارنة أنواع مصادر النفايات التي تدار بشكل صحيح وغير صحيح في دولة الإمارات العربية المتحدة ؛ القواعد واللوائح الحالية المطبقة على قطاع إدارة النفايات في قطاع البناء في الإمارات العربية المتحدة ؛ إحصاءات محددة تصف مشكلة إدارة النفايات في الإمارات العربية المتحدة ؛ عوامل محددة تؤدي إلى إدارة غير فعالة للنفايات وتوصيات يمكن تطبيقها لضمان جودة محسنة لإدارة النفايات في قطاع البناء في الإمارات العربية المتحدة. يجب أن تسهم نتائج مراجعة الأدبيات في فهم كامل للوضع الحالي في مجال إدارة النفايات في الإمارات العربية المتحدة وخارجها. حددت نتائج مراجعة الأدبيات المستوى الفعلي لأهمية القضية ، والمصادر الرئيسية للمشاكل ، والحلول المحتملة التي يمكن تطبيقها لأهداف تطوير التوصيات.

كان على دراسة كمية لجمع البيانات الأولية من 106 مشاركًا أن تساهم في تحديد الوضع الفعلي من وجهة نظر الموظفين والإدارة العاملين في قطاع البناء في دولة الإمارات العربية المتحدة. تم تقديم الطلبات للمجموعات التالية من أصحاب المصلحة المشاركين في قطاع البناء في الإمارات العربية المتحدة للدراسة: المطور ، المقاول ، الاستشاري ، الحكومة ، والقطاع الخاص. وفقًا للنتائج ، كان جزء كبير من المشاركين على دراية بقضايا الاستدامة في مجال عملهم. تم تقييم فعالية ممارسات الاستدامة المطبقة في عملهم على أنها عالية من قبل غالبية المشاركين. من بين عوامل إدارة النفايات ، اعتبر المستجيبون عوامل التكلفة والإنتاجية وتقليل النفايات والمهارات الكافية هي الأكثر أهمية. اتفق المشاركون على أن كلاً من الشركات الخاصة والحكومة يجب أن تولي اهتمامًا أكبر لمجال إدارة النفايات في قطاع البناء. من بين فوائد الإدارة الفعالة لمخلفات البناء ، يركز المشاركون في الدراسة على عوامل خفض التكلفة ، وزيادة الإنتاجية ، وتحسين الصحة ، وتقليل النفايات ، وحماية البيئة ، وتحسين جودة الحياة ، واستخدام المواد بشكل أفضل.

بناءً على نتائج الدراسة ، تم وضع توصيات محددة لقطاع البناء في دولة الإمارات العربية المتحدة بشكل عام. من المهم ذكر النتائج التالية: حاجة الشركات للعمل على إعادة تدوير مخلفات البناء. حاجة الحكومة إلى تطوير مجموعة من القواعد الواضحة والشفافة لتنظيم إجراءات إدارة النفايات ؛ متطلبات الأعمال التجارية لزيادة مستوى وعي وتثقيف الموظفين بشأن قضايا الإدارة المستدامة للنفايات ؛ وإعطاء الأولوية لإعادة استخدام نفايات البناء. مجتمعة ، يجب أن تساهم هذه التدابير في تحويل ممارسات إدارة النفايات في دولة الإمارات العربية المتحدة لزيادة الإنتاجية والفعالية.

Table of Contents

1.0. Introduction

1.1. Background

Over the last few years, the UAE has been experiencing a considerable amount of growth as shown by the development of its construction industry. However, the development of the given industry has not been all positive as it has continued to raise issues on sustainability due to the amount of waste that is generated. According to Al-Hajj and Hamani (2011), construction waste has been defined differently by various institutions. For instance, the Building Research Establishment (1978) stated it is "the difference between materials ordered and those placed for fixing on building projects" (Al-Hajj & Hamani, 2011, p.2). More so, in the 1990s, the Environmental Act defined construction waste as "scrap material or an affluent or other surplus substance arising from the application of any process" (Al-Hajj & Hamani, 2011 p.2). Amidst these definitions, Al-Hajj and Hamani (2011) affirm that construction waste refers to the byproducts that come about from construction itself and also other processes it involves such as rework and demolitions. Therefore, it is vital to consider all the byproducts of the construction process including metals, plastics, and even blocks that remain after it is finished.

Construction waste emanates from multifaceted sources including design, procurement, culture, operations, and handling. Excessive off-cuts arising from poor design are a critical source of construction waste (Al-Hajj & Hamani, 2011). This means that waste within the industry begins from the onset especially if the design is ineffective. Procurement leads to construction waste because of the counterproductive delivery methods, poor quality of materials, as well as inadequate supply chain management. In addition, operations result in construction waste because of such aspects as rework, time restraints, and unskilled labor. Furthermore, handing accounts for construction wastes because of damages arising from transportation, inappropriate storage, and

poor knowledge of the products. Lastly, culture worsens the problem owing to the lack of incentives to regulate waste disposal and absence of training. The construction waste that is generated from all the listed sources goes directly into the environment leading to landfills that degrade land, contaminate water, as well as pollute the air. Understanding the sources of construction waste is necessary as it allows coming up with strategies to ensure it is effectively managed and ultimately reduced.

1.2. Problem Statement

The rise of construction waste is one of the biggest challenges the nation is currently facing. On the one hand, the country is enjoying a remarkable economic contribution due to the growth of the construction sector. Yet, on the other hand, it has also resulted in construction waste, which in turn, poses a significant risk to the environment in the UAE. Accordingly, the UAE continues to demonstrate a substantial amount of struggle in efforts towards achieving the appropriate level of sustainability in its construction industry. According to Swain (2018), construction and demolition waste are responsible for 70% of the total solid waste generated from this Middle Eastern nation. This figure is illustrative of the seriousness of the issue and the need to put in place a clear course of action to minimize the waste. It is vital as the waste ends up in the environment in the form of landfills, which ultimately destroy land and water resources across the country. Therefore, to overcome the problem, it is obligatory to develop measures to regulate construction waste including promoting awareness within the project teams, approaches such as recycling, and using an efficient supply chain (Al-Hajj & Iskandarani, 2012). Addressing the problem consistently is important to ensure that sustainability is attained through waste reduction.

1.3. Significance of the Study

The study is significant because it will help to raise awareness regarding the need for sustainability within the construction sector in the UAE that can be achieved by regulating construction waste. In the past, emphasis was placed on the important role that the construction industry played in the UAE while overlooking the key issue related to sustainability in the sector. Currently, as much as the growth of the industry has been encouraged, fewer efforts have been put toward attaining sustainable outcomes in the industry. Thus, this study is significant because it will assist in understanding the urgency of working toward sustainability rather than just fostering the growth of the industry. Eventually, findings of this research will contribute to the development of environmental initiatives that the UAE can adopt in its management of construction and development waste.

2.0. Research Methodology

2.1. Research Approach

The research approach taken in this paper is divided into 4 stages, namely, literature review, the quantitative method applied through the survey that was distributed to the sample size of 106 participants, the analysis of the results, and the generation of recommendations.

2.2. Literature Review

Literature review is designed to explore relevant research presented in online publications and various articles to provide insights into the problems highlighted by this study. Firstly, different types of construction and demolition waste were discussed to form an understanding concerning the subject of research. Secondly, the disposal of C&D waste streams was analyzed, with the most and the least hazardous types being identified. Thirdly, the review discussed the waste that is properly eliminated in the UAE, defining how the related procedures are performed. Fourthly, information regarding the improper disposal of construction waste was provided, with the possible reasons for failures being suggested. Finally, the review justified relevant laws and regulations as well as the entities that support them, thus contributing to the emergence of sustainability.

2.3. Survey

The survey was chosen as a primary research method to collect data from 106 respondents who work in the construction sector. Since the methodology entails purposive sampling, the research was supported by highly accurate data as people who work in the industry offer more valid details as compared to those that examine the industry only from the outside. The survey was created via the online platform Survey Monkey to enhance the convenience for the respondents and researchers both. It made the survey easy to access for the former and

allowed the latter to analyze data more quickly. Both scale and multiple-choice questions were provided to determine the attitude of the respondents to different elements of sustainability in the construction sector as well as to waste management practices.

2.4. The Analysis of Results

The analysis of results was conducted on the basis of the survey by applying a descriptive method to specify and assess research outcomes. The main objective comprised analyzing each question separately, connecting them to each other and to the literature review performed earlier. It was necessary to identify to which extent the information obtained in literature review matched the data collected from the primary research. The correlation between the datasets was considered to justify the fluctuations and differences as well as similarities between them. Each question was supported with the answers of the respondents, representing the statistics and percentage of negative and positive attitudes. Some questions aimed to represent to what extent the respondents consider some issue relevant for sustainability in the construction sector.

2.5. Recommendations

After the data were collected and analyzed, the recommendations concerning future implications of the study and the overall tendency of the development of sustainability in the construction sector were provided. In addition, the relevance and intricacies of further research were formulated, which is essential as the discovered limitations may affect other results. Overall, the methodology allowed collecting the data, categorizing it, as well as analyzing and comparing it to determine how the conducted research fits in the broader context of sustainability in the construction sector.

2.6. Research Aim and Objectives

The research aim of this study is to carry out an analysis of construction and demolition waste and negative environmental impact in the UAE and explore potential approaches towards its reduction to achieve high levels of sustainability within the country's construction sector. The objectives of the study are;

- To identify different types of construction waste and their effects
- To identify the construction waste with the highest adverse influence
- To identify measures, tools & policies to address construction waste management

2.7. Research Questions

The particular research questions that this research study aims to answer are;

- What are the construction and demolition waste streams in the UAE, and how they are disposed of?
- What is the impact of construction waste in the UAE on the environment?
- What are the current rules and regulations with regard to the disposal of construction waste in the UAE?
- What changes and actions are necessary to improve the situation in the UAE and make the industry more sustainable?

2.8. Research Analysis

The knowledge produced along with the survey results were analyzed through tables and figures to produce valuable insights. Accordingly, the necessary recommendations were made.

3.0. Literature Review

This chapter explores the research that has been conducted on the topic in regard to sustainability within the construction sector. It addresses the aspect of construction waste with regard to what it is, its effects, and measures taken to dispose them. Additionally, it focuses on the type of waste with the highest impact. Finally, it sheds light on some specific UAE statistics and measures taken for disposal of C&D waste in the UAE.

3.1. Different Types of Construction & Demolition (C&D) Waste

Various C&D waste streams are generated by construction projects. These streams can be of different types and forms; some exist as solids while others as liquids. According to Swain (2018), in the UAE, C&D waste streams constitute a considerable part of solid waste generated in the country. The city of Dubai generates an astonishing 5.000 tons of it daily. Abu Dhabi also generates a huge amount of C&D waste contributing to a staggering 71% of waste a year (Swain, 2018). The rates of C&D waste streams generation in the country have become an issue of growing concern given their negative environmental implications (Al-Hajj & Iskandarani, 2012). The situation is even more burning because of the lack of an effective management plan; the situation is threatening to make C&D waste streams an uncontrollable problem. Accordingly, different C&D waste streams are to be discussed to come up with the best management strategy.

Concrete, Tiles, Ceramics, and Bricks

Concrete is one of the C&D waste streams generated by construction companies. Anejo (2014) explicates that this type of waste is not hazardous but can be quite voluminous since it occupies too much space. Brick is C&D waste stream that these companies generate. However, bricks are not necessarily a type of hazardous C&D. Nonetheless, it is possible for bricks to acquire a hazardous nature if they are contaminated and mixed up with other construction waste (Al-Hajj

& Iskandarani, 2012). Tiles are also a common form of the C&D waste stream that is generated by contractors (Al-Hajj & Hamani, 2011). They are usually generated during demolitions and renovation projects. Similarly, to the bricks, tiles are hazardous to nature when they are mixed up with other waste.

Insulation and Asbestos

Insulation is a common component of buildings of different kinds; therefore, it is a form of the C&D waste stream. Asbestos is used in construction as a material that allows buildings to stand against corrosion and provides them with heat (Tam & Lu, 2016). Specific components of buildings that result in this type of waste include pipe, ceiling, and wall insulation, as well as floor backing. It is essential for this type of C&D waste streams to be carefully handled because of its hazardous nature. Insulation as a form of the C&D waste stream becomes hazardous the moment when it is contaminated. For instance, asbestos, bitumen, and mortar are sources of contamination of insulation.

Paints, Adhesives, and Varnishes

These forms of C&D waste streams are generated in the course of new construction and are left following the completion of the work. Regarding paint, waste is generated in the form of paint cans, paintbrushes, and paint removers (Udawatta et al., 2015). This category of the waste stream also includes organic solvents, varnish remover, and adhesive containers. These waste streams are quite hazardous to nature.

Metal and Cable Waste

Metal is another form of the C&D waste stream. It exists as either ferrous or non-ferrous metal. Ferrous metal is usually extracted from various bits of concrete (Anejo, 2014). It is done using hydraulic excavating equipment. Normally, the metal is stored in containers, but at times

when it is not well stored and is left in open field and construction site instead, it can pose danger to the community and environment. On the one hand, nonhazardous metals can be recycled (Ogunmakinde et al., 2019). On the other hand, there are metals that are hazardous; for this reason, they are to be handled very carefully. The cable is also waste that emerges during the construction and demolition (Ogunmakinde et al., 2019). It is another common form of waste.

Adhesives and Sealants

Adhesives and sealants are other forms of the C&D waste stream. This waste is produced by households. Adhesives and sealants are types of waste streams that are quite dangerous to the environment due to their hazardous nature (Al-Hajj & Hamani, 2011). The reason as to why they are considered hazardous is because they contain organic solvents. For this reason, it is critical for workers handling this type of waste to be protected with the help of clothing and other preventive measures (Ogunmakinde et al., 2019).

Wood, Glass, Plastic, Cardboard, and Paper

Wood, glass, and plastic are examples of inert materials that are generated during construction and demolition. Wood is another example of the C&D waste stream (Anejo, 2014). This is the main material in C&D waste streams. The waste that is generated in the form of wood from construction and demolition includes sawdust, shavings, chip wood, and plywood. Glass is also a common form of waste that is generated in the course of construction and demolition. Glass comes from windows of buildings, door panels, and glass shelves and mirrors, for example (Al-Hajj & Hamani, 2011). Plastics are also identified as a form of the C&D waste stream. Some forms of plastics generated from construction and demolition are plastic sheets, plumbing pipes, and Styrofoam insulation (Ogunmakinde et al., 2019). Another type of the C&D waste stream is cardboard and paper. This waste is present in C&D debris. In addition, this waste stream is

generated as a result of the delivery of construction materials and removal of packaging. Accordingly, construction managers have the responsibility of developing effective waste management strategies for cardboard and paper generated by the entire project (Tam & Lu, 2016).

Coal, Tar, and Bituminous

Coal and tar also are forms of C&D waste streams in construction sites. Both coal and tar are hazardous wastes. Bituminous is a mixture of coal and tar. It is a hazardous C&D waste (Al-Hajj & Hamani, 2011). Consequently, there is a need to ensure its safe transportation, storage, use, and ultimately disposal.

3.2. The Disposal of C&D Waste Streams

In most nations of the world, including the UAE, C&D waste streams are considered harmless. At the same time, they are perceived as a form of inert waste that is not problematic. However, these waste streams comprise large masses of materials that are usually disposed of without any consideration (Nelles et al., 2016). Therefore, this approach leaves room for illegal deposits of different forms of waste. In addition, C&D waste contains hazardous elements that can percolate into the ground (Babor et al., 2009). In such a manner, it is imperative to apply the best methods of disposing of these waste streams. Several methods used to dispose of C&D waste streams are discussed in the following subsections.

Recycling

This method of disposing C&D waste is considered the most environmentally friendly approach. It is possible to recycle most of the common C&D waste (Tam & Lu, 2016). In such a manner, waste as concrete, bricks, metals, tiles, and rigid plastics can be recycled. Some of the ways, through which recycling can be done include the following. The dirt, rock, and sand are forms of C&D waste that can be recycled by using it as a landfill cover. Wood is another form of

C&D waste that can be disposed of and used for biomass (Anejo, 2014). In addition, it is possible to recycle wood by reclaiming it or through composting the wood. C&D waste such as concrete may be recycled by transforming it into aggregate or turning it into new concrete products. The concrete together with ceramic waste can be crushed and utilized as rubble (Babor et al., 2009). It is also possible to utilize recycling as a method of disposing of metal. For instance, metal waste such as steel and copper are valuable for recycling. The metal can be smelted and converted into other useful products. In addition, masonry is another essential form of C&D waste that is recyclable. In this case, this waste can be crushed and used in road bases (Ogunmakinde et al., 2019). Accordingly, recycling as a method of disposing of C&D waste makes a considerable difference to the environment. It is also possible to recycled insulation. One of the ways to achieve this aim is the direct reuse of recovered cutoffs (Foo et al., 2013). Another way is carrying out reclamation and reprocessing following removal of any potential impurities that can be harmful, for example, nails or screws.

Incineration

Incineration is a method of disposing of C&D waste through combustion. This process takes place at considerably high temperatures (Al-Hajj & Hamani, 2011). The significance of incineration is to transform the waste into its base components. It is a useful method of disposal of waste because it also results in the generation of heat that can be utilized for other purposes. At the same time, it demonstrates the extent of sustainability of this method of disposal (Al-Hajj & Iskandarani, Reducing Waste Generation on the UAE Construction Sites, 2012). However, this sustainability is brought into question due to the by-products of incineration, which can be quite polluting to the environment. Nonetheless, this problem can be addressed through the use of powerful filters that prevent pollution.

Landfill

Landfilling is a popular method of disposing of C&D waste streams; construction companies have been using it for a long time (Foo et al., 2013). Particularly, this method of disposal has been commonly utilized for solid waste streams. For instance, it is a widespread practice for stone waste to be disposed of with the help of landfills. It is a rational approach due to the large volume of this waste that makes it difficult to be managed (Al-Hajj & Iskandarani, Reducing Waste Generation on the UAE Construction Sites, 2012). Usually, it is done after adequate preparation of the base of the landfill for the disposal. Particularly, a form of protecting lining is placed. In this case, it is significant since it serves as a kind of a barrier between land and groundwater that can be easily polluted by the waste. At the same time, the landfill can be covered with non-porous soil for the purpose of preventing any potential accidental leakages of toxic chemicals (Udawatta et al., 2015). While landfilling is the most used method of disposing of C&D waste streams, with time, it has proven to lack sustainability. The gas of the waste that is disposed of in landfills can move to the nearby structures and territories. This situation is dangerous because it poses the risk of an explosion (Udawatta et al., 2015). Nonetheless, C&D waste streams, including concrete and timber, are the main types of waste disposed of in these landfills. Nevertheless, it is dangerous to dispose hazardous C&D waste streams in a landfill. Consequently, there have been increased calls to utilize other methods that will promote the sustainable disposal of these streams (Al-Hajj & Iskandarani, Reducing Waste Generation on the UAE Construction Sites, 2012).

Junk Hauling

Junk haling by professionals is among the methods used for disposing of C&D waste. It is usually considered a normal part of the construction. Many contractors have resorted to this method of disposing of the waste as a way of protecting revenue since site cleanup by workers will

require time and human resources (Babor et al., 2009). Consequently, outsourcing site cleanup through junk hauling has become a good method of disposing of the C&D waste. Companies specializing in the junk hauling in C&D sites use professionally trained people who are able to sort different types of waste and dispose of them appropriately (Foo et al., 2013).

Open Dumbing

It is another common method of disposing of C&D waste streams. Open dumbing entails dumbing the waste into open spaces, for example, the corner of construction sites or a secured piece of land. The method is commonly utilized by contractors that do not want to place much effort in the disposal of their C&D waste (Al-Hajj & Iskandarani, Reducing Waste Generation on the UAE Construction Sites, 2012). In addition, this method of disposal is used in regions that do not have specific rules and regulations for the C&D waste stream disposal. Accordingly, open dumbing is a method that is highly insufficient (Foo et al., 2013). It results in contractors dumbing in the open C&D waste streams that may be hazardous. However, other regions allow for non-hazardous C&D waste to be disposed of in this way. Timber and concrete can be disposed of through open dumbing, as well (Tam & Lu, 2016).

Composting

It is another common method for the disposal of C&D waste. The method is rather easy and utilizes a natural bio-degradation process. Therefore, it is best for organic C&D waste (Anejo, 2014). Such waste is present in the construction site, as well. It includes the uneaten food that workers bring with themselves to the construction suet. It also includes various plants for construction. It is a good method of disposing of the waste because the compost that is produced by the method can be used by farmers in the future for fertilizing the soil for different crops (Al-Hajj & Iskandarani, Reducing Waste Generation on the UAE Construction Sites, 2012). However,

it is essential to note that composting is a slow process; in most instances, it requires a considerable amount of space. At the same time, rodents and offensive odors make this method of disposing of waste quite unfavorable (Udawatta et al., 2015). However, it remains advantageous because it is a method of waste disposal that allows less waste to be transferred to the landfill.

3.3. Construction Waste with the highest Impact on the Environment

The type of construction waste with the highest impact on the environment is concrete. According to Anejo (2014), this product is made of cement and several other aggregates that are mixed up with water. The use of cement in the manufacturing of concrete is vital because it is one of the biggest contributors to the emission of green gases that contribute to the occurrence of climate change (Anejo, 2014). Concrete is the main construction waste; it is the byproduct of the construction process. It is also generated during the demolition and renovation.

In their study, Babor et al. (2009) explain that one of the key reasons as to why concrete is the construction waste with the highest impact on the environment is the fact that it is the most commonly utilized material in construction and thus the most common waste generated. Concrete is the most used material on earth after water. Anejo (2014) asserts that, if the concrete was a country, it will be the third-largest emitter of carbon dioxide. It is quite a worrying comparison of this building material and waste. In such a manner, it means that concrete could have surpassed the giant nations of the world, including China and the USA, in the emission of carbon dioxide thus severely damaging the environment.

Anejo (2014) explains that concrete is the most commonly utilized construction material because it serves as the foundation of modern development. A historical analysis of architecture and construction reveals that this material has been used since time immemorial. Some of the purposes, for which concrete has been utilized during human history include defense fortification,

roofing material, and a source of structure for various industries such as housing, healthcare, and transportation (Anejo, 2014). Consequently, concrete is one of the ways, in which humans have attempted to tame nature. For example, houses constructed using concrete have provided people with protection against natural elements for many centuries. They protect against the rain, wind, and cold. Accordingly, the substantial benefits of concrete have to a considerable extent hidden the enormous dangers that it poses to the environment.

The Solidity of Concrete Negatively Affects the Environment

The solid nature of concrete is the initial point that causes it to have a negative impact on the environment. Anejo (2014) affirms that concrete is a common construction material because of its solid characteristics. However, the excessive nature of this characteristic has proven to be a negative factor in the face of natural disasters. At this time, the environment fights against concrete demonstrating just how much of a false friend this material can be. In such a manner, due to its solidity, concrete can resist nature for decades (Babor et al., 2009). However, this situation will eventually come to an end when this construction material finally amplifies its impact thus harming nature. Good examples of such an instance are urban centers. Babor et al. (2009) note that urban centers experience adverse effects of floods due to various weather conditions such as hurricanes. The negative influence of concrete contributes to the inability of streets to soak up the water. Therefore, Babor et al. (2009) conclude that concrete cannot provide protection in the case of extreme weather conditions and only aggravates the situation instead.

Surface Runoff Is a Form of Negative Effects of Concrete on the Environment

At the same time, concrete leads to negative environmental effects because of the act of surface runoff. According to Babor et al. (2009), surface runoff in this regard refers to instances when water runs off water-resistant surfaces. In such a manner, if surfaces cannot soak up the

water, it skids off them. An example of when such a situation happens is when water runs off non-porous concrete that is water-resistant. It results in damage to the environment for a number of reasons. First, water can cause severe cases of soil erosion (Babor et al., 2009). Second, this water can contribute to the occurrence of floods. At the same time, when this water run-off takes place in urban centers, which are made of concrete predominating in buildings, walls, and roads, the water picks up numerous waste materials as it runs off. For instance, the water may pick up trash, heavy metals, motor oil, and other pollutants from different surfaces, for example, parking lots or sidewalks (Babor et al., 2009). If attenuation is not appropriate, the situation worsens as the water causes several times the amount of runoff that has been initially generated. This problem has been a reason for the water quality problem in urban centers.

Contractors following the realization of the negative effect of water in the manner described above have attempted to find ways of addressing this issue. Consequently, an emerging solution is the use of pervious concrete. Anejo (2014) explores this idea in more detail and asserts that this type of concrete has the potential to enable automatic stormwater management. Therefore, it allows the water to sip through this concrete. The environmental benefit of this kind of concrete includes the prevention of floods and a contribution to the replenishing of groundwater. At the same time, this type of concrete can play the role of a water filter. Anejo (2014) asserts that it can become e reality only if the concrete is designed and layered well. In this regard, it is possible for this concrete to prevent harmful substances, for example, oils, from passing through and thus protecting land and groundwater.

Carbon Dioxide Emission

Carbon dioxide is one of the most harmful gases to the environment. The negative effects of concrete on the environment are also illustrated in the fact that it magnifies the weather

condition, from which it provides protection. The problem is that this construction waste emits approximately 4-6% of carbon dioxide (Babor et al., 2009). In addition, concrete mixture results in an extensive carbon dioxide emission. An estimated, 0.5 tons of this gas is produced during the decomposition of limestone (Babor et al., 2009). Operating ready mix trucks also adds some amount of carbon dioxide to the environment. Because of its emission, high percentages of carbon dioxide are produced thus making concrete one of the main wastes contributing to global warming. The reason is that carbon dioxide absorbs heat from the surface of the earth. In such a manner, concrete prevents this heat from bouncing back off into space and thus contributes to global warming (Babor et al., 2009).

Visual Pollution

Visual pollution is another example of the negative effects of concrete waste generated by construction. First, the concrete is usually stored in enormous piles following retrieval from the construction site. According to Anejo (2014), these piles can rise high or spread out on masses of land. The piles are quite an eyesore that affect the environment. In addition, the land where these piles of concrete waste are stored is polluted as a consequence of the carbon dioxide emission that is taking place.

Water Pollution

The negative effect of concrete on the environment is further demonstrated in its role in water pollution. An illustration of this is demonstrated in the disposal attempts of concrete by contractors, particularly during the construction process. For instance, on average, each ready mix of concrete returns an estimated one-and-a-half cubic meter of cement daily. Next, following the discharge of concrete, there remain 300kgs of solid waste in the form of cement, stone, and sand (Babor et al., 2009). This amount requires about 1.000 liters of water (Babor et al., 2009).

Therefore, the recycling of concrete through the reclamation of sand and gravel requires a substantial amount of water being used. The damage of concrete to water and this the environment is further illustrated in how the water utilized in the reclamation flows over various sources of this precious commodity. In such a manner, the water that is used is many times directed towards insufficient settling basins and local watercourses.

Excessive Energy Consumption

Energy consumption is another negative effect of concrete on the environment. It can be used in various ways, in which concrete is recycled. The recycling of concrete takes place through the recovery of aggregates. It is essential to take note of the fact that it usually represents only 2% of the total fresh concrete and concrete sludge that remains after the reclamation of aggregates (Anejo, 2014). They are then mixed up with water resulting in the creation of cement paste, sludge. The paste is then de-watered, dried, and crushed. The resultant product can be used in the replacement of some fine aggregates. However, the most suitable use of this product is soil conditioning. This process of recycling requires considerable use of water. Nonetheless, the contractors attempt to minimize this negative effect by saving the water that is used to make other concrete proportions. According to Babor et al. (2009), these attempts are significant because they allow for the full recycling of the concrete. It is further essential to point out the fact that the process usually results in the use of a substantial amount of energy. This issue contributes to global warming and thus climate change. The recycling process of concrete also has negative effects on the environment because of the emerging dust. It is even more so because the recycle of the dust is a difficult task. This process will need to encompass the treatment of its alkaline nature. The most suitable method of tackling the negative effect of this dust is collecting it and putting it back

into the recycling process. Mechanical collectors can facilitate the process of such collection and fabric filters.

Urban Heat

The occurrence of the phenomenon of urban heat is an additional illustration of the negative effect of concrete. The literature indicates that concrete is among the key contributors to the phenomenon of urban heat island (Anejo, 2014). Urban heat island is an urban area that is warmer as compared to the surrounding rural areas. Therefore, when concrete waste is disposed of in such areas as landfills, there is a possibility that these areas will have higher temperatures. This situation requires adjusting areas to find ways to lower temperatures. For instance, surrounding residential areas are likely to make more use of air conditioners. The adverse effect of this strategy is the additional use of energy.

Toxic and Radioactive Contamination

At the same time, concrete waste from construction adversely impacts the environment because of toxic and radioactive contamination. According to Babor et al. (2009), certain substances present in concrete are toxic and radioactive. These substances include useful and unwanted additives. For example, some natural radioactive elements are present in concrete, for example, potassium and thorium.

3.4. C&D Waste that is Properly Disposed of in the UAE

Concrete, tiles, ceramics, and bricks

These types of wastes are well managed by the construction sector in the UAE. In fact, concrete, tiles, ceramic, and bricks are considered the most widespread waste in this sector ("New Resolution by UAE" 2019). In such context, the process of recycling meets two goals at the same time — namely, it increases the efficiency of construction and material use as well as decreases

potential harmful effects caused by the waste. According to "New Resolution by UAE" (2019), 40% of materials must come from recycling performed by using building and demolition aggregates. Concrete and bricks are not hazardous themselves, but they can cause a significant damage when mixed with other hazardous liquids and solids. For this reason, the issue is carefully addressed by the construction sector to ensure that the waste is processed and properly disposed of for further usage.

In the UAE, the companies recycle the biggest part of waste by using two-stage concrete recycling system or landfills. The waste is separated depending on the quality of materials to determine whether it should be recycled or disposed of to a landfill. When the quality of materials is high, they are more likely to be used more than once; otherwise, the waste must be eliminated. Regarding recycling, in the UAE, this process occurs in two stages by using high-pressure borer to crumble the waste and straining the comminuted waste to remove the unnecessary downfall ("New Resolution by UAE" 2019). The system works well for the country, which allows it to use the recycled materials for construction of large projects. For example, at the Expo 2020 construction site, 53% of asphalt mix used to surface thirty thousand under-construction park spaces was derived from the recycled waste ("New Resolution by UAE" 2019). The standards are well-defined and strict for concrete, tiles, ceramics, and brick waste management, which allows the UAE's construction sector to contribute to the trend of sustainability.

Metal and Cables

Gulf region is considered a center of metal scrap recycling, with the UAE and Saudi Arabia being the leaders in this area. Annually, the UAE recycles five million tons of metal scrap for reuse while from seventy to ninety thousands tons are sent for re-export each month ("UAE Recycles 5 Million Tons" 2019). Both metal and cables can be quite hazardous to the environment, which is

why the country addresses these issues to ensure that the construction sector maintains sustainability. Since the development of infrastructure in the UAE is extensive, the companies often use metal construction. The demolition processes are frequent, which is why it is important to manage the waste properly, ensuring that the environmental harm is avoided.

The most prevalent method of metal and metal cables disposal is incineration, which entails the combustion of wastes at high temperatures. It is effective as the re-melting process uses only 5% of energy requirements and produces only 5% of carbon dioxide emission while contributing to the effective waste disposal ("UAE Recycles 5 Million Tons" 2019). However, not all recycled waste is reused by the UAE only. The country re-exports about 40% of metal scrap to India, China, and Pakistan, whish positively affects the economy of the state ("UAE Recycles 5 Million Tons" 2019). In this regard, it is evident that the UAE contributes to the sustainability and establishes an additional budgeting stream by exporting metal to the neighboring countries. The future perspectives in such context are also promising as the construction industry is still on the rise, which will allow the UAE to advance its efforts in achieving sustainability and improve the technologies of recycling to reduce the energy use along with CO2 emission.

Coal, Tar, and Bituminous

Two decades ago, the UAE faced a major problem that stemmed from the improper disposal of coal, tar, and bituminous. By moving the waste to an open pit, the country attempted to determine the most effective way of waste management. Such strategy resulted in the increased environmental harm caused by excessive amounts of badly disposed bituminous (Shareefdeen et al. 2020). However, currently, the UAE has managed to reduce the negative impact of waste by using the innovative waste-to-energy technologies, the practice that was initiated by Dubai, Abu-Dhabi, and Sharjah. This revolutionary method entails the processing of solid waste, including

coal, tar, and bituminous, transforming it into renewable energy. It constituted 10% of renewable energy production in 2019 (Shareefdeen et al. 2020). Such system allows procuring large amounts of energy, reducing the adverse impact of waste, while also contributing to sustainability by providing the state with the ability to manage the waste and improve the efficiency of its energy sector.

The problem is that landfills is no longer an effective and appropriate method for waste management in the UAE. The reason for this is that the country grows at a fast pace and the landfills cannot accommodate such vast amounts of waste without producing harmful effects. The UAE is a leading country in terms of sustainability, and currently, it is implementing a consequential program of adoption of waste-to-energy plants. At the moment, waste generation in tones a day equals 3524, but this number is anticipated to grow up to 5622 tons in 2030 (Shareefdeen et al. 2020). It means that the country has sufficient chances to use solid waste, processing it into energy that will positively affect both construction and energy sectors, thus contributing to sustainability promotion across the whole Gulf region.

Wood, glass, plastic, and paper

The UAE focuses on plastic waste management as the effect of plastic on the environment is exceptionally harmful. In fact, whilst wood, glass, and paper can be easily recycled via incineration (burning) and composting (bio-gas degradation), such methods do not work with plastic (Zakaria 2018). Hence, the most effective way to reduce the impact of plastic pollution is to apply regulations aimed at the reduction of plastic in the daily usage. In the present days, this problem remains highly relevant in the UAE, and the government addresses it in multiple ways, such as through awareness campaigns and taxation systems. Plastic usage directly depends on the personal responsibility of each resident. Currently, an average resident uses 450 plastic bottles in

a single year, which makes the UAE one of the biggest bottle consumers in the world (Zakaria 2018). This issue is hard to manage as the only way to reduce the harmful effect of plastic pollution is to scale down the waste across the country.

Even though the problem affects the environment adversely, it is remarkable that the state addresses it sufficiently enough to ensure that the impact of pollution will be reduced by 2030. In particular, the government of the UAE initiates the replacement of plastic drinking straws with paper straws, encourages people to adopt a greener lifestyle and stop using plastic in their daily use, launches awareness campaigns to demonstrate the extent to which the effect of plastic pollution is harmful, and rewards the usage of recyclable plastic materials (Zakaria 2018). Given that the construction sector is rapidly growing, the entities within it are highly encouraged to use plastic minimally and dispose of it properly to stop the worldwide disaster.

3.5. C&D Waste that is NOT Properly Disposed of in the UAE

Insulation and Asbestos

Considering the fact that the insulation becomes hazardous under the conditions of contamination and that asbestos can start this process, it is important to manage both elements in combination to prevent the harmful effects they can cause. Unfortunately, despite the nationwide ban, asbestos is still used in construction as its replacement is costly (Todorova 2015). Since many new projects are launched annually, the use of asbestos and insulation does not decrease, thus negatively contributing to the sustainability of the construction sector. Worse yet, the government does not control it sufficiently, and as Todorova (2015) notes, more than 15 construction companies in the UAE admitted to the regular usage of these materials. In light of the above, it is clear that the problem is relevant as its consequences are highly negative. The state does not address the issue effectively to ensure that the regulations are strict and the laws are followed.

The reasons for the lack of proper regulations concern the fact that the level of awareness is low and the government does not provide diligent control over the policies it implements. For example, the problem of plastic pollution is addressed sufficiently as the community is aware of the harmful effect it causes. The hazardous impact of asbestos and insulation is as significant as that of plastic, but due to the comparatively low level of awareness, the problem is omitted and 95% of asbestos waste is disposed of via the landfills (Todorova 2015). Another reason is that the UAE does not control the companies within the sector, and despite the ban, the material is still used. If the government controlled the issue more effectively, the use of insulation and asbestos would be reduced. The problem can still be managed if the UAE starts paying diligent attention to the use of different construction materials for future projects, ensuring that asbestos is no longer exploited.

Paints and Varnishes

Paints and varnishes waste are extremely hazardous for nature, but in the present days, is the UAE still manages it poorly. The main indicator that the issue is omitted is that no governmental waste management program mentions paints or varnishes, giving the priority to other groups, such as plastic, metal, and concrete. Nevertheless, the issue is relevant as the chemicals contained in the paints and varnishes produce a highly adverse impact on nature. The disposal of waste to the landfills negatively affects the sustainability of the construction sector. The percentage of paints and varnishes waste remains critical as the material is considered as a leftover of finished construction projects. Multiple paint cans, brushes, and removers are constantly used at the construction site, which is why their improper disposal is a critical issue that threatens the whole industry.

Ideally, the paint should not be disposed of until it is dry enough to crumble. Dennehy (2018) notes that prior to recycling the cans or brushes, they must be fully dry as it allows removing the paint residue and purifying the objects from any chemicals. The UAE does not address the issues of paint waste management as while all other processes are described in detail, the paint and varnish waste ones are neglected. It is also important to remember that the determinant for the efficient waste management is the availability of waste data (Dennehy 2018). As long as such data remain available and easily accessible, the state can develop the alternative methods of management that will fit the particular needs of the sector. When data are unavailable, it is impossible to develop the coherent plan for waste management to reduce the hazardous environmental impact. Hence, any waste management practices must be supported with evidence and include paints and varnishes disposal — otherwise, the government will not be able to manage the problem.

3.6. Importance of Effective Waste Management in the UAE Construction Sector

The discussion of the scale of waste management issues existing in the UAE construction sector demonstrated the relevance of changes adopted in this sphere. Together with the definition of the specific waste categories and products that should be effectively managed to mitigate the negative impact of waste on the environment, it is important to highlight the key arguments for the importance of improvement of waste management practices. The realization of the recommendations developed in this study would require additional financial and operational costs. It is sensible to demonstrate the potential benefits of such a decision.

Wide list of prior studies aimed to consider the potential benefits of improved waste management in construction projects. The research by Hwang & Yeo (2011) highlighted the following categories of operational benefits gained from the effective management of waste in

the construction sector: cost-saving and profit maximization; reduced demand for landfill spaces, improved resource management; image improvement; productivity and quality improvement (p.396). Effective management of waste in the construction facility could also lead to the reduction of costs for waste transportation, recycling, and reuse (Hasmori et al 2020, p.3). It is important to remember that the waste that has to be further managed and recycled is the inventory, which was purchased earlier by the organization for specific construction tasks. A high level of accumulated waste in the construction project can be considered as a serious indicator of poor quality of inventories planning and utilization.

Together with the direct impacts and benefits for the construction sector businesses, benefits for the wider community and external stakeholders must be summarized. Narcis et al (2019) defined key external benefits of improved waste management as the reduction in negative environmental impacts due to waste, reduction in public health and social issues caused by waste, and the reduction of ineffective usage of natural resources in the economy. The generation of waste from construction materials leads to the excessive usage of natural resources in the production cycle of society, leading to the exhaustion of the environment. For the UAE, the problem of ineffective usage of natural resources and inventories is especially relevant since the state does not obtain independent resource base on its territory. Since the UAE economy must import a major part of inventories and resources, the problem of effective usage of inventories is relevant for the UAE society.

In this aspect, the question of efficient and sustainable waste management can be considered as a strategic objective not solely for the UAE construction business in general, but for other stakeholders, mainly including the government of the UAE. From the perspective of potential risks of high dependency on imports, state actors in the UAE should be motivated to

encourage sustainable waste management practices as a mean of business independence promotion. This condition is especially relevant for the large construction projects, which take long-term period for practical realization. For example, in case if the construction company in the UAE aims to invest in the production of new skyscraper and orients on application of imported natural resources and materials, it is important to guarantee sustainable usage of available resources to avoid additional trade and political risks. Modern world is characterized with the rising volume of international trade and political risks (Hoke et al 2019). In case if the company might lose access to the specific resource because of sanctions and trade barriers, it is important to guarantee most sustainable and efficient application of available volume of this resource.

The negative impact of poor quality of waste management in the UAE should also be considered from the point of negative impact on the environment. In this way, ineffective waste management in the construction sector of the UAE economy could lead to the following undesirable outcomes: soil contamination; water contamination; climate contamination; air and marine life contamination (Metropolitan Transfer Station 2017). The problems of water, climate, and air contamination are most relevant for the UAE since this country is placed in a specific climate zone and has limited access to the sources of freshwater. In such conditions, improper attitude to the limited scope of natural resources and climate conditions could lead to negative outcomes for the UAE society in general. The resolution of the waste management issue in the UAE construction sector must be considered as a serious contribution to the overall well-being of a wide range of stakeholders in the country.

3.7. Factors that lead to Ineffective Waste Management in the UAE

A separate question of the study that must be addressed to reach a full understanding of the issue of waste management quality in the UAE construction sector is related to the definition of factors that lead to poor effectiveness in this sphere. Alternative views on this question were presented in prior studies. One of the most complex visions of the factors that impact the quality of waste management in the UAE was provided in the study by Narcis et al (2019). This study identified 17 key causes of ineffective waste management in the construction sector. Following categories of causes could be identified as most dangerous for the industry: wastage due to cutting; change of design; workers errors; lack of on-site materials control and management plan; severe weather conditions; errors in tender documents; poor storage of materials; over-mixing of materials; wastage due to theft and transportation damage; accidents on site and malfunction of equipment (Narcis et al 2019, p.10). Together with the stated factors of poor waste management, the impact of the following factors was identified: lack of knowledge and education of effective waste management practices; no incentives and motivation for the realization of effective waste management practices; lack of ownership of waste on sites due to multiple contractors structure; lack of interest to waste management in the design of construction projects (Narcis et al 2019, p.16). Taken together, a high share of causes of ineffective waste management is caused by the mistakes of stakeholders directly engaged in the processes of waste management and construction project realization. Such finding leads to the conclusion that effective solutions could be identified to prevent the negative impact of waste management in the UAE construction sector.

Together with the existing causes of poor quality of waste management inside the organization, it is sensible to consider factors that could generate risks for waste management

outside the company. These factors could hardly be managed by the business organization. Their identification is important for the management team to understand what factors could not be impacted but could affect waste management risks in the future. Mohammed et al (2020) identified the following categories of external factors of poor waste management: procurement factors; site conditions; and a large group of external factors identified by external stakeholders of the project (pp.4-5). Procurement factors include congestion of the construction site; interference of other crews at the site; poor site conditions and waste caused by the poor quality of materials packaging. To address these issues, management of the project in construction must pay high attention to the identification of site conditions and means of materials packaging. Among the key site conditions that should be monitored, the following were considered as a key to success or failure of the waste management processes: unforeseen ground conditions; difficulties in access to the construction site; leftover materials on site, and lighting problems (Mohammed et al 2020, p.4). Finally, a wide list of additional external factors that could impact the quality of waste management processes organization included the following: effects of weather; antiacceleration; accidents; unpredictable local conditions; lack of legislative enforcement; high vandalism level and damage caused by third parties (Mohammed et al 2020, p.5). Taken together, to succeed in the sphere of waste management, the project team in the construction process must address a large scope of challenges.

The final category of causes of poor quality of waste management that should be considered included supply chain issues. The research by Udeaja et al (2013) identified the following categories of the supply chain issues faced by modern construction business: lack of integration in the industry; lack of knowledge and training in effective supply chain management for the construction projects; poor suppliers commitment; nature of clients and customers; supply

chain specify challenges (p.12). Taken together, a low level of effectiveness in cooperation between suppliers and construction business leads to the generation of specific risks that could be effectively mitigated in case if the management of the construction project paid proper attention to this question. As a result of the absence of a sufficient level of knowledge and experience in the sphere of waste and supplier relations management, the construction business is not capable to mitigate potential challenges of poor waste management that could be easily addressed in alternative conditions.

To summarize the information about the key causes of poor quality of waste management in the construction sector, the findings of the study by Nagapan (2011) must be presented. According to the results of the study, the following categories and types of risk factors were identified: **Design** – frequent design changes in the construction projects; **Handling** – wrong storage of construction materials; **External** – effect of weather; **Management** – poor planning of construction project and required materials; **Procurement** – ordering errors; **Workers** – workers mistakes; **Site Condition** – leftover materials on site. It will be important to perform a quantitative study in the context of the presented research to identify whether similar categories of risks could be considered as vital for the UAE construction sector, or situation in the UAE is characterized by the impact of the unique factors and conditions.

3.8. Best Practices in the Sphere of Waste Management for Construction Sector

The final question that must be presented in the context of the literature review is the discussion of the best practices that could be applied to improve the quality of waste management in the construction sector. A discussion of this question should contribute to the development of specific recommendations for the UAE construction sector after the presentation of the study results. Specific insights and recommendations should be based not solely on the

findings of quantitative study and participants survey, but also on the assessment of specific practices that demonstrated effectiveness in the global construction sector practice in the past.

A general set of guidelines for effective waste management in the construction sector was provided by the Zero Waste Scotland initiative. According to the stated arguments of the report, the following categories of activities were identified as a key to successful waste management: waste reduction; re-using of materials; recycling waste (Zero Waste Scotland 2018). For the objective of waste level reduction in the construction projects, the following initiatives were considered as vital: deliveries planning to avoid excess and material spoilt; material storage; minimization of material movement; avoidance of damaged materials; elimination of excess packaging; the practice of materials return to the suppliers in case of possibility (Zero Waste Scotland 2018, pp.13-14). For the aspect of materials re-use in the construction sector, the following solutions were offered: adequate planning of materials re-use in the construction project and definition of best alternative means of materials application (Zero Waste Scotland 2018, p.15). The idea behind the re-use of materials is that useful inventories that could be applied in practice should not be transformed into waste. Finally, in the sphere of waste recycling, the following initiatives were highlighted: materials segregation practice; engagement with waste contractors; staff & sub-contractor training for waste recycling; effective storage of materials (Zero Waste Scotland 2018, pp.16-17). Taken together, a wide range of solutions was identified as a potential contribution to the effective management of waste in construction projects.

Another study by Dania et al (2010) contributed to the definition of the specific steps that must be taken by the management of the construction projects to guarantee high quality of result in the sphere of waste management. According to the recommendations stated by the

researchers, the following conditions should be created for the promotion of best waste management practices in business: managerial support of waste management; motivation for waste minimization; staff education and training; material storage practices training; estimation & ordering practices improvement; recycling infrastructure development; design issues addressing through the integration of waste management objectives; material supply quality improvement; waste disposal costs monitoring and minimization (Dania et al 2010, p.128). In this way, management of the construction project must play an active role in the promotion and support of waste management initiatives among stakeholders of the project.

These recommendations were supported by the findings of the study by Hasmori et al (2020), which also provided a set of recommendations for different sources of risk in the sphere of waste management for construction projects. According to the study results, five groups of recommendation solutions were developed. In the first category of recommendations, addressing the needs of **Human Resources**, the following recommendations were identified: improved education on waste management, the appointment of the waste manager on site; prevention of waste generation by staff. In the second category of recommendations, **Materials & Equipment** recommendations were considered. The following solutions were offered: prevention of over-ordering materials; proper selection of materials; oriented on highly recycled materials; avoidance of unnecessary packaging; Just-in-time delivery method; proper storage practices.

Among the **Construction Method** recommendations, the following solutions were vital: effective communications at the construction site to avoid waste-generating practices; periodic control of waste management practices applied; promotion of best practices of materials reuse among staff; keeping the site clear to avoid the generation of additional waste. **Administrative** measures of waste management included the following: standardization of design and materials;

minimization of design changes in the project; supply chain alliances development; waste auditing practices; distribution of responsibility for waste management with sub-contractors; recycling targets set for all phases of the project; rules of dealing with waste-generators; adequate planning and correction of waste-generating activities (Hasmori et al 2020). Finally, **Regulation** activities oriented on minimization of waste issues should include the development of the Site Waste Management Plan (SWMP), contractual clauses to penalize poor waste management practices, waste management requirements for tenders, the definition of waste management levels in relations between client and contractors (Hasmori et al 2020). All these initiatives were found to play a positive role in the promotion of the best waste management results in the construction sector.

In the context of the identified initiatives for improved waste management processes in the construction sector, similar propositions were delivered in the research by Ajayi et al (2016). Taken together, prior studies contributed to the definition of a diversified set of recommended solutions that could help the construction business to address the problem of poor waste management with the support of internal and external stakeholders. Effective operations of the project management, engagement of the staff in the process of waste management procedures optimization, and effective cooperation with the external stakeholders of the project should contribute to the realization of the optimal result from the point of waste management outcomes improvement. It is important to consider the existing situation in the sphere of waste management for the UAE construction sector and identify the applicability of the proposed solutions there.

3.9. Current Rules and Regulations for Disposal of Construction Waste in the UAE

According to the analysis of the legal framework of the UAE, several laws regulate waste management in the country.

Federal Law No. 24

One of these laws is the Federal Law No. 24 of 1999 (Singh, 2014). This law was established with the purpose of improving the protection and development of the environment. It has been referred to as the Federal Environmental Law. The law provides essential details concerning the federal legislative framework fostering the environmental regulation in the country. Some of the main points of consideration covered by this law include the following issues:

- Protecting and conserving the environment through ensuring quality and natural balance;
- Fostering the development of natural resources and supporting biodiversity;
- Controlling the pollution and preventing immediate negative effects;
- Complying with established international laws on environmental protection.

The mentioned law was one of the earliest pieces of legislation that set rules and regulations in waste management in the UAE. The law covers interesting concepts regarding waste management and environmental protection. However, it does not provide any specific guidelines on the management of C&D waste streams. In such a manner, less than two decades ago, the UAE did not have effective waste management regulations and rules.

Environmental Legislation Law No. 21

The UAE'S laws and regulations concerning waste management are also issued at the local level (Singh, 2014). It is crucial to view and apply these laws as a means of supplementing the federal laws. Nonetheless, it is essential to note that federal laws are more important in the case of

any ambiguity. For instance, in Abu Dhabi, the agency that is responsible for waste management is the Environment Agency Abu Dhabi. There are some specific laws that have been established for the location regarding waste management. One of these laws of environmental legislation is Law No. 21 of 2005 (Singh, 2014). On the other hand, in Dubai, the same duties are carried out by the Dubai Municipality Environmental Department.

Federal Law No.61

It often happens that Emirates apply laws independently from each other; thus Dubai has issued the Local Order No. 61 of 1991 (Singh, 2014). This law was enacted long ago. Therefore, this fact indicates that Dubai has to develop laws that will be able to deal with the current issues related to waste management. At the same time, this law indicates that the city has been dealing with waste management in general for a long time already and has good experience in the field. Therefore, new laws that will be enacted should include waste management as it relates to the construction industry. It is especially vital because Dubai is the emirate that has experienced a substantial development and thus high levels of construction, including generation of waste (Singh, 2014).

Dubai Free-Zone Law

Several laws for waste management have also been enacted to provide rules and regulations to free zones in the UAE. This step was vital since the free zones were areas in the UAE, which operated independently to a certain extent. Nevertheless, these zones require laws that will regulate waste management because the adverse effects of inadequate waste management can be felt throughout the UAE (Singh, 2014). Accordingly, in relation to Dubai, various free zones in this region have own regulations on the management of environmental issues. An example is the Trakhees (Ports Customs and Free Zone Corporation). This zone has developed its own regulatory

department for Environment Health and Safety that is referred to as EHS (Singh, 2014). The role of the department is to regulate and enforce rules and regulations regarding environmental protection in such domains as water, marine life, and air.

Sharjah Waste-to-Energy Law

Another example is the eco-friendly project launched by Sharjah Emirate to connect two ultimate needs of the country, those of energy production and waste management. The government of the UAE extensively supports waste-to-energy technology as it is highly efficient and allows generating energy via incineration of Municipal Solid Waste Feedstock (MSWF) since the percentage of MSWF per capita in the country is high. As compared to the USA, where MSWF per capita equals 2.1 kg, in the UAE, this number can reach up to 2.7 kg (Shareefdeen et al. 2019). More than that, the conditions for recycling in the USA are better as the geographical location of the country allows it to dispose of the waste effectively. However, against the background of intensive growth of the country, the amount of waste increases exponentially while the ability to recycle it remains on the same level. From this perspective, waste-to-energy initiative is one of the most effective methods for the UAE to produce green energy and recycle MSWF at the same time.

Climate Change Resolution

Through the Ministry of Climate Change and Environment, the UAE has issued several rules and regulations concerning the disposal of construction waste. One of these regulations is the Ministerial Resolution Number 21 of 2019. This resolution was passed last year; it aimed to improve the recycling of construction waste. The specific requirements of this resolution include the following. First, construction projects that are conducted in the country have the responsibility of utilizing 40% of the recycled aggregate materials. It must be done within their construction projects. This specific requirement applies to projects in both the private and public

sectors. Second, this resolution asserts that contractors are responsible for ensuring that they dispose of construction waste responsibility. It is done while recycling what is possible. In addition, materials are to be recycled according to the specifics of the established UAE standards. This resolution strived to ensure that there would a bit less carbon footprint and the environmental wellbeing of the planet would improve.

In view of the resolution, the government also set strict standard regarding the aggregates to process concrete and other solid waste into the material that can be reused. One of the most famous investment companies that adopted the regulation is EMAAR Properties, that prioritizes the importance of concrete recycling, which boost the efficiency of construction and contribute toward sustainability ("New Resolution by UAE", 2019). Since the construction sector is intensively growing in UAE, the problem is dangerous as the prodcution oof solid waste is major. According to As long as the law functions, the construction companies are compelled to adopt recycling procedures and adopt the construction process to meet the highest quality and recycling standards.

Waste Management Database Regulation

Since the UAE is a progressive and highly-modernized country, it used the chance to adopt modern tracking technologies to facilitate the process of waste management. In 2018, the Ministry of Climate Change and Environment launched the project named "Waste Management Database". The regulation implied the crowding of all national structures into a single system that could allow reporting and tracking the processes of waste management across the country on the annual basis (Dennehy 2018). According to the governmental vision, the system can simplify waste management by indicating the areas that must be addressed due to posing a threat to the environment. Many private and governmental entities, including construction companies and the

state, supported this initiative, confirming that the system will favor waste disposal practices (Dennehy 2018). Given that previously, the ministry faced the problem of inaccurate data collection, the database will eliminate this problem, ensuring that waste management will be proper and based on the relevant analysis of the available information.

Asbestos Ban Policy

As soon as the world acknowledged the danger of asbestos use, many developed countries started to ban the material as it cannot be recycled, producing a critically negative effect on the nature. In 2006, the UAE ordained the law that fully prohibited the use of asbestos in construction (Todorova 2015). However, the reality differed from expectations. The law was proven to be ineffective, the level of awareness was reduced, and the ban did not actually work, even though the policy went nationwide. Regretfully, the state stopped its attempts to provide sufficient regulations, concentrating on other pollution issues instead. As a result, the problem is still immediate and poorly managed by the Ministry of Climate Change and Environment. For the UAE's government, it is relevant to address the issue sufficiently and renovate the policy, applying strict penalties for those who violate it.

Summary of the Rules

The rules discussed above regarding the UAE's regulations for disposal of construction waste demonstrate the legal framework of the most developing nations. Many of these rules and regulations were established some time ago. Consequently, they are quite insufficient in dealing with contemporary issues relating to waste management. At the same time, these rules and regulations are not specific to the construction industry. However, those rules and regulations that have been established recently are connected with this industry to a certain extent. This point

is significant because it demonstrates that the UAE understands the construction industry as a major producer of waste in the country.

Exploring the compliance and penalties for companies that engage in activities that are harmful to the environment reveals the rules and regulations of the UAE's waste management. However, a closer look at compliance and penalty standards shows that they are mainly focusing on companies involved in the extraction of oil and gas. It is a significant issue given that the UAE is among the Arab states with huge oil reserves. Nonetheless, it is essential to highlight some of the fines that those who cause harm to the environment incur in order to get an idea of what companies operating in the construction industry may expect. Companies that extract oil are prohibited from pollution; in case they are found guilty of any malpractice, they will incur fines of between USD 55,000 and USD 135,000 (Sigh, 2014). In addition, the punishment can also involve receiving a sentence for the pollution that can last for two-five years. This sum is quite a substantial amount to be paid as fines.

Through the assessment of rules and regulations of the UAE's waste management, it emerges that more needs to be done to enable the establishment of waste management strategies that will adequately tackle C&D waste streams.

3.10. Statistics about the UAE

Rise in the number of construction projects. The research conducted on construction waste in the UAE and its management reveals some useful statistics concerning this issue. According to GlobalData (2018), the construction industry in the UAE regained its growth momentum in 2017 with its output expanding to 3.9% up from 3.0% from 2016. The growth has been instrumental in impacting construction waste. Currently, the UAE is considered one of the biggest producers of

construction waste given the rapid development of this state. The country's economy is the largest growing economy in the Middle East resulting in it becoming the largest construction market.

Statistics about effects of construction industry. In fact, 75% of waste in the UAE comes from construction waste (Al-Hajj & Hamani, 2011). To be more definite, the amount of construction material that was dumped in the Dubai landfill in 2007 was approximately 27.7 million tons (Al-Hajj & Hamani, 2011). This was quite a substantial amount of construction waste because it was almost three times the volume of construction waste that was generated in the previous year. More importantly, the amount continued to increase the following year with 2008 being a year when it doubled when compared to 2007 (Al-Hajj & Hamani, 2011). It should also be highlighted that that the UAE and its counterpart Saudi Arabia are the top two generators of waste per capita globally (Al-Hajj & Iskandarani, Reducing Waste Generation on the UAE Construction Sites, 2012). The UAE is ranked second after the US in waste share per capita in the world. The mentioned above facts point to the urgent need for change in the way that the UAE manages its construction waste as the fact that its amount has risen to unprecedented levels in recent years indicates the inefficiency of its management.

3.11. Summary

As per this chapter, sustainability is an issue that remains challenging to the UAE and the world over. Economic growth in the UAE has contributed to the rise of the construction sector. While this has been beneficial to development it has also had adverse effects on the environment thus the increased concern for sustainability.

4.0. Results and Discussion

In this chapter the key results of the study are presented utilizing graphs developed from SurveyMonkey. It is worth noting that the data entailed answers to various questions connected to sustainability within the construction sector in the UAE. The data are presented, and discussions follow each of the pieces of the data linking the results to the findings of the literature review.

1. Please specify your gender

Question 1 was aimed at identifying the respondents' gender. The impact of gender on the results of the study is significant given that the gender distribution is unequal within the industry. For this reason, it was important to choose men for the study in order to enhance the accuracy of the data obtained. Question 1 depicted that eighty-seven percent of participants were male, whilst just 13% were female. Since the actual percentage of the respondents aligned with the estimated distribution in the industry at large, the validity of the research results was ensured. The greater number of male participants meant that the greater degree of questions was answered by men, who could provide much more insightful information on the sustainability issue in the construction industry compared to women due to the quantitative superiority of male employees over female employees.

2. Which organization do you work for?

Question 2 was aimed at identifying the type of organizations the respondents worked for. However, it should be noted that the results of the second question are not particularly significant to the research since the construction industry in the UAE is actively developed by both private and governmental sectors (Mack 2019). In fact, the UAE's government supports the construction sector in every possible way since it is an important part of the country's economy. Presently, the industry grows extensively with an expected CAGR of 5.5.% over the period between 2019 and

2024 (Mack 2019). Such an extensive growth of the industry is justified with the conduction of the Expo 2020 that required a major contribution of the government to the development of the construction sector. Moreover, the issue of sustainability is prioritized in order to ensure that the construction sector will provide sustainable results, which is essential in realizing the UAE's global development plan and enhancing the country's contribution to environment protection.

Question 2 defined five possible groups such as developer, contractor, consultant, government, and private sector to identify the affiliation of the respondents to one of the groups. However, the respondents could also to point out any other group if none of the predetermined ones was applicable. The greatest percentage of the respondents, namely forty-six percent, were employed in the government sector. From this perspective, it was possible to assume that the accuracy of the answers of those working in the government sector would be high; this is because the UAE's government prioritizes the issue of sustainable construction, seeking to achieve the highest level of sustainability (Mack 2019). In fact, the government oversees all construction projects carried out within the country. Further, prior to launching the project, the government estimates the extent of its sustainability. Since almost the half of respondents work for government, the expected level of construction sustainability awareness is high.

As to other groups, six percent of the respondents were developers, twelve percent were contractors, nineteen percent were consultants, and seven percent worked in the private sector; lastly, ten percent belonged to "other unidentified groups". Based on the answers to the second question, the assumption concerning the accuracy of the data was that it would be high since the respondents were chosen from different types of organizations. This would allow for assessing the problem from numerous perspectives. Notably, it would be incorrect to rely solely on the answers of workers from one sector, as their awareness of the issue might be limited. However, for the

purposes of this research, half of the respondents were government employees, whilst the second half was distributed among multiple groups, which allowed for reviewing the issue multilaterally.

3. What is your job position/role in the sector?

Question 3 was aimed at identifying the job positions held by the respondents within the sector specified in the previous question. Depending on the job position, the level of sustainability awareness might vary due to the difference in both expertise and experience of the respondents. Evidently, those holding top positions would have more knowledge regarding the issue under discussion, thereby providing more insightful information for the analysis. On the other hand, those holding lower positions would mainly provide supportive data. Based on the industry review conducted prior to the questionnaire, thirteen occupations were identified that the respondents were the most likely to hold. These occupations included a lead architect, an architecture team member, a lead construction manager, a construction team member, a lead consultant, a consultant team member, a lead engineer, an engineering team member, a lead project manager, a project team member, a lead quantity surveyor, a surveying team ember, and a senior manager/director. As an additional option, the respondents were able to choose the "other" category that did not require specification.

Since it was determined that senior positions were more likely to provide better insight into sustainability issues in construction, it was relevant to separate them from lower-level positions. Thus, lead architect, lead construction manager, lead consultant, lead engineer, lead project manager, lead quantity surveyor, and senior manager/director were distinguished as top positions while all other positions were considered as low-level positions. In percentage terms, one percent of the respondents were lead architects, six percent were lead construction managers, four percent were lead consultants, six percent were lead engineers, eleven percent were lead project managers,

one percent were lead quantity surveyors, and eighteen percent were senior managers/directors. In total, the percentage of the participants holding top positions was forty-seven percent. For the research, the percentage relationships were beneficial since the majority of the answers were provided by more experienced employees, whilst the rest of the respondents provided supportive data.

Overall, the percentage of low-level positions was twenty-nine percent. To be more exact, six percent were construction team members, nine percent were consultant team members, six percent were engineering team members, nine percent were project team members, and two percent were surveying team members. Despite the fact that the majority of the respondents held higher-level positions, it was ultimately relevant to consider the answers of all the respondents, as this allowed for assessing the issue from multiple perspectives. It is important to note that the issue of sustainability is emphasized on all organizational levels in the UAE in order to ensure that all employees realize the importance of developing sustainable construction projects (Al Huraimel 2019). Given this fact, it was critically important to compare the perceptions of low-level positions to those of high-level positions. Ideally, the perceptions should be similar since all employees of an organization must be united around the same vision and goal of creating sustainable projects, which will bring great benefits to the UAE. However, the actual perceptions might differ because some organizations poorly manage the dissemination of organizational values across different levels.

4. Are you aware of sustainability issues in the construction industry?

Question 4 was aimed at identifying the respondents' awareness of sustainability issues in the construction industry. The issues were not specified in the questionnaire on purpose; in that way, the answers provided by the participants would be based only on their personal knowledge

and perceptions. Prior to assessing the percentages obtained in the fourth question, it is relevant to specify the particular sustainability issues meant in the question. According to Yilmaz and Bakis (2015, p. 2255), some of the sustainability issues in the construction industry include energy and pollution, materials and waste, and sustainable procurement. Since each domain is equally important in ensuring sustainability of construction projects, it would only count if the respondents were aware of the issues specified. However, the purpose of the fourth question was to conduct preliminary assessment; the issues themselves would be examined in more detail in the following questions. Anyway, this preliminary enabled the researchers to set certain expectations concerning the forthcoming results.

Each sustainability issue specified above is critical in any construction project. Firstly, companies are responsible for energy consumption and pollution that might damage the environment. Yilmaz and Bakis (2015, p. 2257) claim that the use of energy affects sustainability either directly via the creation of buildings and infrastructure or indirectly through the operational phase. The most affluential indicator of sustainability in this case is either partial or full utilization of renewable energy. The second issue is construction that must be disposed of appropriately; it is crucial to eliminate any hazardous waste that might cause serious harm to the environment (Yilmaz & Bakis 2015, p. 2259). The strongest indicator of sustainability in this case is the extent to which the disposal of waste is planned. When the waste is disposed of in full compliance with ecological regulations, the project can be considered as fully sustainable. The last sustainability factor is procurement; this factor which deals with the acquisition of goods and services in such a way as to ensure the best value for money (Yilmaz & Bakis 2015, p. 2261). In case all these issues are perceived appropriately by the respondents, the answers to the fourth questions are expected to be positive.

While answering question 4, eighty-two percent of the participants indicated that they were aware of sustainability issues in construction. In their turn, eighteen percent of respondents provided a negative answer to this question. It is also important to note that none of the respondents skipped the question. This means that all of them realized the meaning of the question, even though not all of them turned to be aware of sustainability issues. Since almost one fifth of the sample stated that they were not aware of sustainability issues, this presented a significant limitation for the study. On the one hand, the impact might be serious as the percentage was relatively high. On the other hand, the impact might not necessarily be major since it was not clear what specific occupations were held by the respondents who had provided negative answers. Given that the majority of participants held top positions, the assumption is that the minimal quantity of them might have provided a negative answer, as the level of senior employees' awareness of sustainability issues is high in the UAE (Al Huraimel 2019). In case the negative answers to the fourth question were provided by those holding low-level positions, the accuracy of the research would not be affected significantly.

5. How effective have you found sustainable construction principles when applied to construction projects?

Question 5 was aimed at identifying the perception of the effectiveness of sustainable construction principles. The results indicated that twenty-four percent of the respondents assessed the effectiveness of sustainable construction principles either as "very effective" while forty-four percent assessed it as "effective". Consequently, the majority of the participants agreed that the effectiveness of sustainability principles was high. However, the degree of assessment still varied. Whilst twenty-four percent assessed the sustainability principles as "very effective", these results turned out to be inconsistent with other research data. For example, according to Yilmaz and Bakis

(2015, p. 2255), the application of sustainable construction principles has highly positive effect on the sustainability of construction projects. Moreover, the UAE's government majorly supports sustainable projects, which means that the high efficiency of sustainability principles is perceived on all levels of government. Nevertheless, only twenty-four percent of the respondents indicated that the application of the principles was very effective, which constituted a significant difference between the ones who chose "effective" and those who chose "very effective". This discrepancy indicated that the respondents did not perceive the importance of sustainable construction principles to the full extent; otherwise, the majority would have assessed the effectiveness of the principles higher.

At the same time, twenty-five percent assessed the effectiveness of sustainability principles as "satisfactory", which also indicated that a significant portion of participants perceived the effectiveness of sustainable construction principles inappropriately. In fact, Reddy (2016, p. 522) claims that the effectiveness of sustainability principles can be perceived from different perspectives depending on the area of consideration; still the effectiveness is exceptionally high in each domain. For example, the appropriate use of clean energy directly contributes to the sustainability of construction projects due to the deduction in the CO2 emissions. Another example is appropriate processing of waste materials; according to sustainability principles, the disposal must be fully safe for the environment, which proves their exceptional effectiveness. Hence, the percentage of those choosing "satisfactory" does not align with the data obtained from the literature.

Surprisingly, six percent assessed the effectiveness of sustainability principles as "ineffective" while and one percent assessed it as "very ineffective". Given that eighteen percent gave a negative answer to the question concerning the awareness of sustainability issues, such

results can be attributed to the low level of the respondents' awareness. Notably, eighteen percent indicated lack of awareness in the fourth question while the rate of those who skipped questions was very low; this means that the respondents might have answered the questions in which they were not proficient. More specifically, the one who is not aware of sustainability issue can hardly assess the effectiveness of sustainability principles in a particular setting. Since such negative results appeared throughout the entire survey, they could be considered as a limitation resulting from the sample portion that indicated the low level of awareness of the sustainability issues.

6. To what extent do you personally agree or disagree that the following factors are associated with the application of sustainable Construction to construction project delivery?

Question 6 aimed to identify the extent to which the respondents agreed or disagreed that the predetermined factors were associated with sustainable construction. These factors included cost, customer, satisfaction, efficiency, productivity, quality, service delivery, time value, waste reduction, workforce, and skills. Thirty-five and forty-nine percent of the respondents, respectively, "strongly agreed" and "agreed" that the costs are associated with sustainability issues. In fact, eighty-five percent in total agreed, thirteen percent were unsure, and only three percent disagreed. Overall, the results indicated that the respondents correctly perceived the importance of costs in sustainable construction, as sustainable principles are directly correlated to the cost growth (Tam & Le 2019). In addition, twenty-one percent strongly agreed that customers are associated with sustainable principles; in total, sixty-two percent agreed, twelve percent were unsure, and two percent either disagreed or strongly disagreed. According to Tam and Le (2019), customers might be demanding in case they prioritize sustainable qualities of the construction. From this perspective, it is possible to claim that the customers play a pivotal role in sustainability of

construction projects, as eighty three percent of the respondents indicated this factor as important one.

As to the satisfaction factor, eighty-five percent in total agreed, ten percent were unsure, and five percent disagreed. Tam and Le (2019, p. 67) claim that satisfaction of all project stakeholders is pivotal in ensuring sustainability. In fact, a project can be considered as fully sustainable in case sustainability factors set by each stakeholder are fully met. Given that the majority either agreed or strongly agreed, it can be concluded that satisfaction with the project directly contributes to its sustainability. Almost the same percentages were identified for the efficiency factor, as eighty-four percent either agreed or strongly agreed that the efficiency is associated with sustainability; similarly, ten percent were unsure while six percent disagreed. Thus, efficiency is also directly correlated to sustainability.

Another important factor is productivity. Seventy-eight percent either agreed or strongly agreed that productivity is associated with sustainability, sixteen percent were unsure, and six percent either disagreed or strongly disagreed. In this case, it is necessary to rely on the survey data fully since no supportive evidence was found. Hence, given the high percentage of those who agreed, productivity is connected to the application of sustainability principles in construction projects, whilst the high level of uncertainty can be explained by the low level of awareness of some respondents.

As for the quality factor, seventy-six percent either agreed or strongly agreed that the quality is directly correlated to sustainability, sixteen percent were unsure, and eight percent either disagreed or strongly disagreed. Tam and Le (2019, p. 98) claim that, depending on the quality, the level of sustainability will majorly vary. Hence, it is critically important to ensure that each element related to sustainability is diligently addressed, agreed on with stakeholders, and

performed outstandingly. This assumption was confirmed by the results of the study since the level of agreement was seventy-six percent, which indicated that the majority of the respondents perceived quality as an important factor that directly correlates to sustainability.

The next factor was service delivery. In total, seventy-six percent either agreed or strongly agreed, eighteen percent were uncertain, and six percent either disagreed or strongly disagreed. According Tam and Le (2019, p. 151), sustainability is connected to service delivery in that sustainable constructions provide high-level service due to the satisfaction of clients' needs. Since the level of agreement was high, the validity of the assumption regarding the factor was proved.

As for the time value factor, seventy-five percent either agreed or strongly agreed that the factor is associated with sustainability, fourteen percent either disagreed or strongly disagreed, and eleven percent were uncertain. The high level of agreement confirmed that the factor is associated with sustainability, even though no evidence was found in the literature.

The greatest level of agreement, namely eighty-six percent, was determined for the waste reduction factor. It is noteworthy that the rate of strong agreement was higher by ten percent on average compare to other factors. Since waste reduction is one of the core components of sustainable construction according to Tam and Le (2019, p. 112), it was proved by the survey that this factor is associated with sustainability. In addition, the level of disagreement and uncertainty identified was six and eight percent, respectively, which is low.

The last two factors were workforce and skills. The agreement rate turned out high in both cases – eighty-two and eighty-three percent, respectively. In both cases, the level of uncertainty was fourteen percent while the level of disagreement was four and three percent, respectively. Given that the disagreement rate was low, it is possible to conclude that both workforce and skills are essential factors that play a significant role in ensuring sustainability of construction projects.

Table 1: Factors of sustainable construction

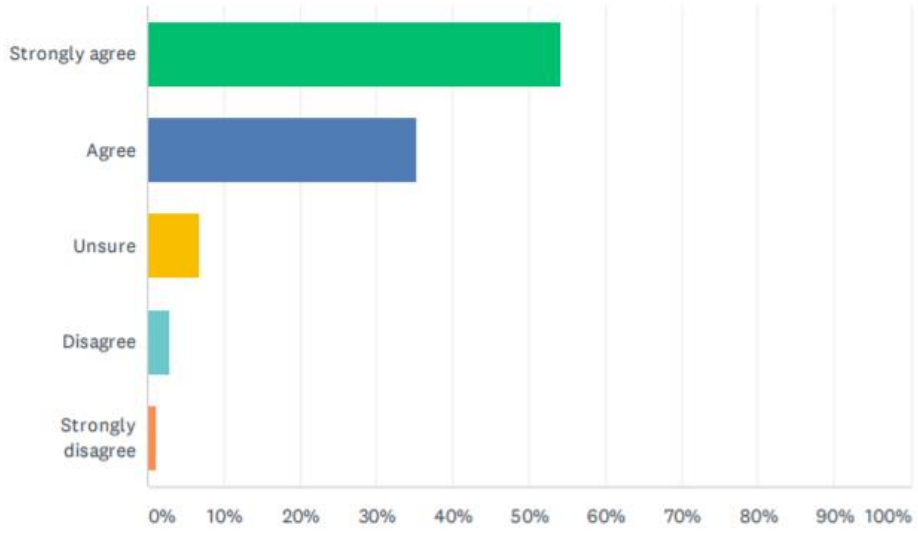
	STRONGLY AGREE	AGREE	UNSURE	DISAGREE	STRONGLY DISAGREE	TOTAL	WEIGHTED AVERAGE
Cost	34.62% 36	49.04% 51	12.50% 13	2.88% 3	0.96% 1	104	1.87
Customer	21.36% 22	62.14% 64	12.62% 13	2.91% 3	0.97% 1	103	2.00
Satisfaction	23.30% 24	62.14% 64	9.71% 10	3.88% 4	0.97% 1	103	1.97
Efficiency	27.88% 29	54.81% 57	9.62% 10	6.73% 7	0.96% 1	104	1.98
Productivity	30.10% 31	47.57% 49	15.53% 16	5.83% 6	0.97% 1	103	2.00
Quality	25.96% 27	50.00% 52	16.35% 17	4.81% 5	2.88% 3	104	2.09
Service Delivery	24.27% 25	52.43% 54	17.48% 18	4.85% 5	0.97% 1	103	2.06
Time Value	26.92% 28	48.08% 50	11.54% 12	10.58% 11	2.88% 3	104	2.14
Waste Reduction	37.86% 39	47.57% 49	8.74% 9	4.85% 5	0.97% 1	103	1.83
Workforce	23.08% 24	57.69% 60	14.42% 15	2.88% 3	1.92% 2	104	2.03
Skills	27.45% 28	54.90% 56	14.71% 15	1.96% 2	0.98% 1	102	1.94

7. Do you think that more efforts should be made by the local construction companies and the government to make the industry more sustainable in the future?

Question 7 aimed to determine whether the companies and government should put more effort into making the industry more sustainable in the future. Fifty-four percent of the respondents strongly agreed that significant effort must be put into improving sustainability in the industry. As

such, more than half of the respondents believe that focus must be on innovations that will increase sustainability in the future. Notably, Yilmaz and Bakis (2015, p. 2256), make a similar assumption, claiming that the key to success in the future lies in a constant advancement of sustainability. Another thirty-five percent agreed to a lesser extent. In sum, the agreement rate was eighty-nine percent, which proved that the majority of the participants perceive the importance of introducing change and improving sustainability in the construction industry. At the same time, the degree of uncertainty was only seven percent. Such a low level of doubt can be attributed to the fact that the question directly encouraged the respondents to apply a what-if analysis in order to predict the future of sustainability under the conditions of constant innovations. Lastly, the rate of disagreement was only four percent, which is a minor indicator for this question. Since the degree of agreement majorly outweighs the level of disagreement, it can be concluded that innovations in the future will favorably affect sustainability in the construction industry.

Figure 1: Efforts toward sustainability



8. Give your opinion on the benefits of construction waste management.

Question 8 was aimed at identifying the respondents' attitude to the factors associated with the impact of construction waste on the environment. Seven such factors were determined in total, namely cost reduction, increased productivity, improved health, waste minimization, environmental protection, better life quality and better use of materials. Overall, seventy-nine percent of the participants assessed the cost reduction factor as very important while twenty percent defined this factor as either important or slightly; lastly, one percent assessed this factor as unimportant. In this regard, Mah et al. (2018, p. 63) claim that cost reduction is one of the most affluential factors associated with construction waste – the cheaper ways of waste processing, the fewer the costs.

Waste was also found to affect the level of productivity. In fact, thirty-one and thirty-five percent of the respondents assessed this factor as very and fairly important, respectively, while thirty percent determined the factor as important; lastly, four percent characterized the factor as either slightly important or unimportant. The results indicate that the level of productivity directly correlates to waste disposal; specifically, productivity tend to be higher where waste disposal is more efficient.

The improved health factor is also directly correlated to the main construction waste. Mah et al. (2018, p. 63) claim that the lower amount of waste decreases its negative impact on people's health over time. This fact was proved by the study since fifty-nine and twenty-two percent assessed the factor as very important and fairly important, respectively; in turn, twelve percent assessed the factor as important, five percent perceived it as slightly important, and one percent indicated that the factor is unimportant.

The next factor is waste minimization. Tam and Le (2019, p. 11) claim that a linear connection exists between the appropriate waste disposal and waste minimization. As for the

survey results, sixty-one percent assessed the factor as very important, twenty-two percent as fairly important, twelve percent as important, three percent as slightly important, and two percent as unimportant. Since the degree of critical significance is high, it can be concluded that the main construction waste affects the environment through waste minimization.

The other two factors are better life quality and better use of materials. Tam and Le (2019, p. 54) note that the appropriate waste management positively affects both the quality of life and the utilization of materials. To be more exact, the authors report a direct correlation between waste disposal and the efficiency of the use of materials. According to the survey, both better use of materials and better life quality were assessed as very important by the same percentage of the respondents, namely sixty-two percent. In addition, both factors were assessed as fairly important by twenty and twenty-three percent, respectively. Further, both factor were found to be important by fourteen and eleven percent, respectively. Finally, approximately four percent in total estimated each of the two factors as either slightly important or unimportant. The total level of perception of the significance of both factors equals ninety-six percent, which proves the assumption made on the basis of the literature review. The final factor is environmental protection, which was assessed as a critical component of waste management by Tam and Le (2019, p. 19). In the survey, eighty-seven percent in total assessed the factor as either important or fairly important, fourteen percent considered it as either important or slightly important, and only one percent defined it as unimportant. This question of the survey also measured the weighted average of each factor. On average, this indicator varied between 1.5 and 1.6; notably, the lowest score (1.5) was for environment protection while the highest score (2.07) was for increased productivity. The results mean that among all factors specified, the environment protection is the most affluential one.

9. Rank the construction waste with the highest impact on the environment on a scale of 1-10?

In order to assess the impact of the construction waste on the environment, twelve groups of possible waste were determined; the respondents were to measure the impact of each factor on a scale of one to ten. These groups included cardboard, masonry, plastics, wood, asphalt, concrete, glass, paper, tiles, dry walls, gypsum, and metal scrap. The plastic was ranked highest in terms of the environmental impact was with a score of 9.4. The answer is logical since, according to Nagapan et al. (2012, p. 331), the impact of plastic on the environment is the most negative one compared to any other construction waste. In fact, forty-seven percent of the respondents ranked plastic the highest on the negative impact scale. At the same time, masonry and cardboard were ranked close to plastics with scores of 8.6 and 8.2, respectively. As noted by Nagapan et al. (2012, p. 331), the recycling of masonry and cardboard helps to prevent deforestation and water loss. Since cardboard and masonry were ranked among top three highest-ranked categories in terms of the environmental impact by fifty and forty-three percent, respectively, it can be concluded, that plastics, cardboard and masonry pose the most significant danger ,for the environment.

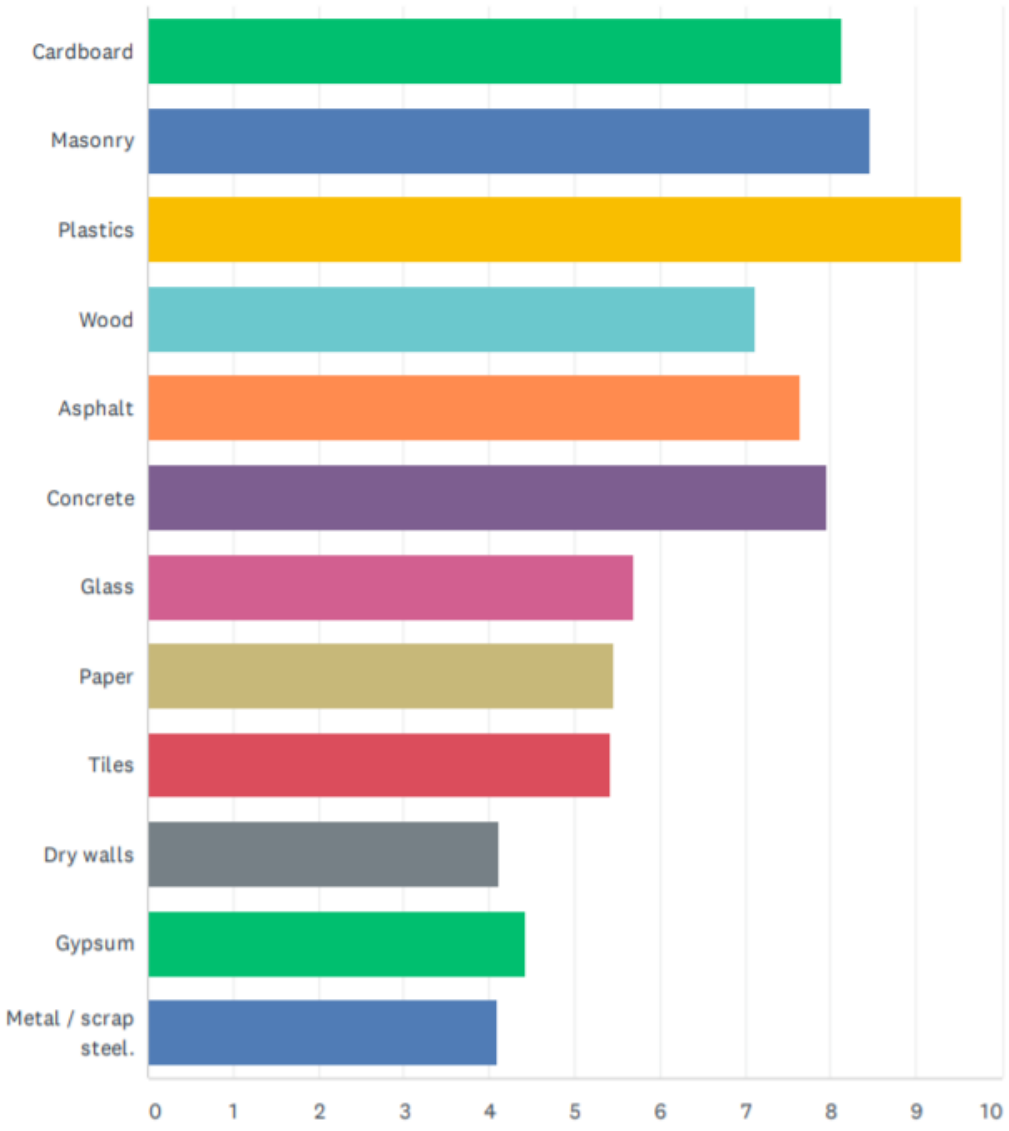
Wood, asphalt and concrete received scores of 7.1, 7.6, and 7.9, respectively. As claimed by Nagapan et al. (2012, p. 332), the greatest negative effect of wood, asphalt, and concrete is their contribution to the increase in carbon dioxide emissions, which, in turn, contributes to climate change. Since the correlation of the CO2 emissions to the wood, asphalt, and concrete is direct, it is essential that companies strive to decrease their harmful impact.

Glass, paper, and tiles were ranked moderate with scores from 5.4 to 5.6. However, Tam and Le (2019, p. 34) state that paper and glass have an indirect negative impact on the environment; for instance, inappropriate recycling of paper leads to deforestation. While it might seem that

negative effect of paper is negligible, the more paper is used inappropriately, the more forests will be cut down. Further, Nagapan et al. (2012, p. 332) noted that reducing paper waste by ten percent will help to save more than 100000 square kilometers of forests. Given this fact, the scores awarded by the respondents seem insufficient. Nevertheless, these types of waste were awarded average scores, which appropriately depicted the relevance of their effect compared to other elements.

Dry walls, gypsum, and metal scrap were ranked the lowest with scores of 4.1, 4.5, and 4.2, respectively. The matter is that these elements have a minor impact on the environment as noted by Tam and Le (2019, p. 112). Hence, these scores can be considered as appropriate to the evidently-supported facts. These results mean that the waste should be recycled in compliance with the priority, addressing the recycling process of each element in such a way as to contribute to sustainable construction.

Figure 2: Types of wastes in the construction sector



10. Rank the importance of benefits of sustainability in construction

Question 10 proposed to rank the benefits of sustainability in construction on a scale of zero to ten. The factors proposed for ranking included cost reduction, increased productivity, improved health, waste minimization, better use of materials, environmental protection, and better life quality. While this question is similar to question 8, the critical difference is that the importance of the factors was assessed individually in question 8. Contrary to this, question 10 suggested an assessment scale, which allowed for depicting the results visually.

Notably, the results turned out to be similar to the ones obtained in question 8. Environmental protection, improved health, and waste minimization were ranked higher compared to other factors; however, the highest score did not exceed 4.5. These results mean that the perception of the issue is insufficient since the respondents mainly provided average scores rather than assessing the factors more critically. The rankings were as follows: cost reduction – 4.1, increased productivity – 3.7, waste minimization and improved health – 4.5, better use of materials – 3.6, environmental protection – 4.2, better quality of life – 3.5. Given that the maximum score was ten and that none of the factors were ranked higher than 4.5, it is possible to conclude that the respondents did not provide radical answers resulting from critical analysis of each benefit.

Table 2: Ranking Importance of sustainability

	1	2	3	4	5	6	7	TOTAL	SCORE
Cost reduction	23.71% 23	12.37% 12	7.22% 7	14.43% 14	8.25% 8	18.56% 18	15.46% 15	97	4.11
Increased productivity	9.47% 9	22.11% 21	10.53% 10	5.26% 5	13.68% 13	14.74% 14	24.21% 23	95	3.67
Improved heath	10.53% 10	14.74% 14	28.42% 27	20.00% 19	16.84% 16	6.32% 6	3.16% 3	95	4.51
Waste minimization	16.67% 16	10.42% 10	17.71% 17	29.17% 28	14.58% 14	6.25% 6	5.21% 5	96	4.46
Better use of materials	4.17% 4	10.42% 10	18.75% 18	9.38% 9	32.29% 31	14.58% 14	10.42% 10	96	3.59
Environmental protection	18.56% 18	18.56% 18	5.15% 5	11.34% 11	10.31% 10	28.87% 28	7.22% 7	97	4.08
Better quality of life	14.43% 14	10.31% 10	11.34% 11	10.31% 10	6.19% 6	12.37% 12	35.05% 34	97	3.39

5.0. Conclusion and Recommendation

5.1. Conclusion

The discussion of the question about the existing situation in the sphere of waste management in the UAE demonstrated the significant impact of this issue on different aspects of industry performance and the engaged stakeholders. The results of the literature review contributed to the definition of key categories of waste generated in the UAE construction sector, disposal of the waste streams, the potential impact of different categories of waste on the environment, existing situation with the disposition of different categories of construction waste in the UAE, current laws and regulations applied to this issue in the UAE and the relevant statistics of the issue of waste management in the country. The results of the review demonstrated that though the diversified model of regulations is currently applied, it does not contribute to the proper effectiveness of waste management. From this point, additional improvements in this sphere will be required in the future.

Results of discussion of the best practices existing in the sphere of waste management improvement in the construction sector demonstrated that the future initiatives will have to be oriented on the following aspects of the construction business: human resources; materials and equipment; construction methods; administrative measures; and regulations in the sphere of waste management. The highest attention should be delivered to the aspect of human resources development. The results of the literature review demonstrated that lack of education and training in the aspects of sustainable application of materials and waste do not allow ordinary employees to reach high efficiency in the sphere of waste management in everyday work. This finding was supported by the outcomes of the quantitative primary data analysis, which revealed the low level of awareness on the issue of sustainable waste management among ordinary

employees in the UAE construction sector. Based on the stated findings of the study, the specific recommendation in the aspect of personnel education and training for the aims of sustainable waste management practices promotion was delivered.

Together with the specific role of personnel in the process of sustainable waste management processes realization, it was stated that the improvement of project management procedures is required. Specific attention should be paid to the issue of improved design of construction projects to make the results of the design procedure more sustainable and oriented on minimization and effective re-use of the construction waste. It was found that the specialists in the UAE construction sector today do not pay proper attention to the question of the efficient design of construction projects from the point of sustainable waste management. In this aspect, it will be important to promote changed corporate culture principles and motivate design teams in construction projects to develop more sustainable solutions.

Specific attention was paid to the discussion of the key factors that were considered as impacting the level of waste management sustainability in the UAE construction sector. Based on the findings of the literature review, it was stated that among the key factors that could impact the efficiency of waste management in the construction sector, both internal and external factors should be considered. While specific sources of risk and opportunity could be effectively managed by the personnel and supervisors in the company, specific conditions including weather changes and mistakes of suppliers could not be effectively managed without a proper understanding of the source of risk. From this perspective, the results of the study demonstrated whether the engaged participants had a clear picture of existing challenges in the sphere of waste management and could effectively apply this knowledge in their practice.

The factor of sustainable construction that was considered as of the highest importance for the UAE construction sector was the parameter of costs. From this perspective, the realization of sustainable construction projects was found to be dependent on the expected costs and benefits of sustainable practices' implementation. In case if the realization of sustainable waste management practices required excessive expenses and losses from the business, it was found to be likely that the sustainability practices would not be considered as desirable. Such an approach demonstrated a lack of understanding of the problem's significance and a lack of support from external stakeholders that could motivate construction business management to perform more sensible policies.

Together with the factor of costs, customer expectations and satisfaction with the fact of sustainable practices implemented in the sphere of waste management were found to have a high impact on final decisions and activity of the UAE construction companies. From this perspective, it could be possible to promote sustainable waste management practices through the generation of strong public support for businesses that apply such approaches. Together with the public promotion of sustainable waste management practices, it was found to be important to deliver means of efficient waste management, to guarantee high productivity and quality of results for a business engaged in this sphere. To promote sustainable practices among representatives of the UAE construction business, it might be sensible to provide conditions for the effective exchange of experience with international colleagues and experts. In case if the UAE business owners and management of the construction companies gain a better understanding of cost-effective and productive means of waste management, better results in this sphere could be achieved.

The discussion of key benefits of sustainable waste management from the point of study participants contributed to the identification of key factors that could be considered to motivate

businesses for more sustainable practices in this sphere. The factors of cost reduction, waste minimization, the better quality of life, and environmental protection were considered as key results of sustainable waste management in the UAE construction sector. It is sensible to promote sustainable waste management as one of the key elements of corporate social responsibility (CSR) policies of the UAE construction sector businesses.

While traditionally initiatives in the sphere of the CSR are considered solely as investments in the company's reputation and public recognition resources, in the case of the UAE construction sector the initiatives oriented on the sustainable waste management could contribute to both objectives: optimization of financial outcomes of business and improvement of corporate reputation level. From the point of financial outcomes for the business, the realization of the specific large construction projects could be associated with reduced costs for business in case of more efficient management of waste, which would make large projects more affordable and less financially risky for business. Such an outcome could also contribute to the more efficient strategic development of business, improving its competitive positions in the UAE and international markets. Considering the question of sustainable waste management from this perspective, it might be easier to encourage representatives of the UAE construction business for sustainable development.

Taken together, the findings of the presented study contributed to the definition of the significant role of sustainable waste management for the future development of the UAE construction sector. This conclusion is explained with the following arguments: significant negative role of waste generation in the construction sector on a large number of stakeholders, the rising volume of construction projects realization in the UAE, existing experience of sustainable waste management implemented around the world, and the definition of potential

financial and reputational benefits from sustainable waste management in the construction business. All these factors serve as a basis for the promotion of more active waste management policies in the UAE construction business. Specific recommendations were delivered for the business and governmental sectors in the UAE to contribute to sustainable waste management in the future.

5.2. Recommendations

The following recommendations need to be followed by both local construction companies in the UAE and the government to attain sustainability:

- Companies should work toward recycling of construction waste materials.
- The government needs to adopt a threshold for sustainability through clear rules and regulations.
- Businesses need to emphasize the aspect of construction waste awareness among their employees for the attainment of sustainability.
- Prioritize the reuse of construction waste materials

Reference List

Ajayi, S., Oyedele, L., Bilal, M., Akinade, P., Alaka, H. & Owolabi, H. (2016). ‚Critical management practices influencing on-site waste minimization in construction projects'. *Waste Management, 59,* pp. 330-339.

Al Huraimel, K. (2019). UAE sustainability drive is built on alliances. Gulf News [online]. [Accessed 4 January 2020]. Available at: https://gulfnews.com/business/analysis/uae-sustainability-drive-is-built-on-alliances-1.68173424

Al-Hajj, A., & Hamani, K. (2011). Material waste in the UAE construction industry: Main causes and minimization practices. Architectural Engineering and Design Management, 7(4), 221-235. DOI: 10.1080/17452007.2011.594576

Al-Hajj, A., & Iskandarani, T. (2012). Reducing waste generation on the UAE construction sites: Conference paper. Ace, Brazil. https://www.researchgate.net/publication/281439841_Reducing_Waste_Generation_on_the_UAE_Construction_Sites

Anejo, J. A. (2014). Impact of concrete, steel, and timber on the environment: A review. International Journal of Technology Enhancements and Emerging Engineering Research, 2(7), 58-63. https://www.ijteee.org/final-print/july2014/Impact-Of-Concrete-Steel-And-Timber-On-The-Environment-A-Review.pdf

Aziz, S. (2019). UAE: tackling waste and environmental pollution. [Online] Available at: https://medium.com/@saniaaziz12/uae-tackling-waste-and-environmental-pollution-4a3019e804dc [Accessed 14 January 2020].

Babor, D., Plian, D., & Judele, L. (2009). Environmental impact of concrete. Bulletin of the Polytechnic Institute of Jassy, Constructions. Architecture, LV (LIX)(4), 27-35. https://www.researchgate.net/publication/40497595_Environmental_Impact_of_Concrete

Brooks, K. A., Adams, C., & Demsetz, L. A. (1994). Germany's construction and demolition debris recycling infrastructure: What lessons does it have for the US. Sustainable Construction, 16, 6-9. https://www.irbnet.de/daten/iconda/CIB_DC24877.pdf

Creswell, J. W. (2014). Research design: qualitative, quantitative, and mixed methods approaches. New York: SAGE.

Dania, A., Kehinde, J. & Bala, K. (2010). 'A Study Of Construction Material Waste Management Practices By Construction Firms In Nigeria'. *Ahmadu Bello University*. Available at: https://www.irbnet.de/daten/iconda/CIB10782.pdf [Accessed 10 November 2020]

Dennehy, J. (2018). New UAE national database to track hazardous and non-hazardous waste., The National [online]. [Accessed on 1 Feb 2020]. Available at: https://www.thenational.ae/uae/environment/new-uae-national-database-to-track-hazardous-and-non-hazardous-waste-1.747946

Esa, M., Halog, A. & Ismail, F. (2015). ‚Waste Management in Construction Industry - A Review on the Issues and Challenges'. *4th International Conference on Environmental Research and Technology (ICERT 2015).* Available at: https://www.researchgate.net/publication/277711259_Waste_Management_in_Construction_Industry_-_A_Review_on_the_Issues_and_Challenges [Accessed 10 November 2020]

Foo, L. C., Rahman, I. A., Asmi, A., Nagapan, S., & Khalid, K. I. (2013). Classification and quantification of construction waste at housing project site. International Journal of Zero Waste Generation, 1(1), 1-5. https://www.researchgate.net/publication/258224538_Classification_and_Quantification_of_Construction_Waste_at_Housing_Project_Site

GlobalData (2018). Construction in the UAE – Key Trends and opportunities to 2022. [Online] Available at: https://store.globaldata.com/report/gd-cn0392mr--construction-in-the-uae-key-trends-and-opportunities-to-2022. [Accessed 24 January 2020].

Hasmori, M., Zin, A., Nagapan, S., Deraman, R., Abas, N., Yunus, R. & Klufallah, M. (2020). ‚The on-site waste minimization practices for construction waste'. *IOP Conf. Series: Materials Science and Engineering 713*. Available at: https://iopscience.iop.org/article/10.1088/1757-899X/713/1/012038/pdf [Accessed 10 November 2020]

Hoke, E., Marada, J. & Heinzova, R. (2019). 'International Trade Risks'. *MATEC Web of Conferences, 292*. Available at: https://www.researchgate.net/publication/335995530_International_trade_risks [Accessed 10 November 2020]

Hwang, B. & Yeo, Z. (2011). 'Perception on benefits of construction waste management in the Singapore construction industry'. *Engineering Construction & Architectural Management 18* (4), pp.394-406. Available at: https://www.researchgate.net/publication/235310315_Perception_on_benefits_of_construction_waste_management_in_the_Singapore_construction_industry [Accessed 10 November 2020]

Mack, B. (2019). UAE construction sector to grow 6-10% in 2020 – KPMG survey., Gulf Business [online]. [Accessed 4 January 2020]. Available at: https://gulfbusiness.com/uae-construction-sector-grow-6-10-2020-kpmg-survey/

Mah, M., Fujiwara, T. & Ho, CS. (2018). Environmental impacts of construction and demolition waste management alternatives. 2018 Chemical Engineering Transactions (CETI). [Accessed 15 December 2019].

Metropolitan Transfer Station (2017). '6 Negative Effects of Improper Waste Management'. *Metropolitan Transfer Station*. Available at: https://www.metropolitantransferstation.com.au/blog/negative-effects-of-improper-waste-management [Accessed 10 November 2020]

Mohammed, M., Shafiq, N., Abdallah, A., Ayoub, M. & Haruna, A. (2020). 'A review on achieving sustainable construction waste management through application of 3R (reduction, reuse, recycling): A lifecycle approach'. *IOP Conf. Series: Earth and Environmental Science 476*. Available at: https://iopscience.iop.org/article/10.1088/1755-1315/476/1/012010/pdf [Accessed 10 November 2020]

Nagapan, S. (2012). Issues on construction waste: The need for sustainable waste management. pp. 329-334.

Nagapan, S., Rahman, I. & Asmi, A. (2014). ‚A Review of Construction Waste Cause Factors'. *University Tun Hussein Onn Malaysia*. Available at: https://www.researchgate.net/publication/258224434_A_Review_of_Construction_Waste_Cause_Factors [Accessed 10 November 2020]

Nagapan, S., Rahman, I., Asmi, A., Memon, A. & Latif, I. (2012). Issues on construction waste: The need for sustainable waste management. 2012 IEEE Colloquium on Humanities, Science and Engineering (CHUSER). [Accessed 15 December 2019]

Narcis, N., Ray, I. & Hosein, G. (2019). 'Construction and Demolition Waste Management Actions and Potential Benefits: A Perspective from Trinidad and Tobago'. *Buildings, 9.*

Nelles, M., Grünes, J., & Morscheck, G. (2016). Waste management in Germany – Development to a sustainable circular economy? Procedia Environmental Sciences, 35, 6 – 14. DOI: 10.1016/j.proenv.2016.07.001

New resolution by UAE climate change ministry to recycle site waste. (2019). Construction Week [online]. [Accessed on 2 Feb 2020]. Available at: https://www.constructionweekonline.com/products-services/169178-uae-climate-change-ministry-unveils-legislation-to-support-construction-waste-upcycling-and-reuse

Ogunmakinde, O. E., Sher, W. & Maund, K. (2019). An assessment of material waste disposal methods in the Nigerian construction industry. Recycling, 4(13), pp. 1-15.

Ogunmakinde, O. E., Sher, W., & Maund, K. (2019). An assessment of material waste disposal methods in the Nigerian construction industry. Recycling, 4(13), 1-15. DOI: 10.3390/recycling4010013

Reddy, V. (2016). Sustainable Construction: Analysis of Its Costs and Financial Benefits. International Journal of Innovative Research in Engineering & Management, vol. 3 (6), pp. 522-525. [Accessed 7 January 2020].

Shareefdeen, Z., Youssef, N., Taha, A. & Masoud, C. (2020). Comments on waste to energy technologies in the United Arab Emirates, Environmental Engineering Research, vol. 25, no. 1, pp.129-134.

Singh, K. (2014). Legislation: Environmental law regime in the United Arab Emirates: An investor's guide to environment compliance in the construction industry. Electronic Journal of Islamic and Middle Eastern Law, 2. DOI: 10.5167/uzh-97709

Slowey, K. (2018). Report: global construction waste will almost double by 2025. [Online] [Accessed 31 January 2020]. Available at: https://www.constructiondive.com/news/report-global-construction-waste-will-almost-double-by-2025/518874/

Swain, S. (2018). Construction wastes management in the UAE. [Online]. [Accessed 30 December 2019]. Available at: https://www.ecomena.org/construction-waste-uae/

Swain, S. (2018). Construction wastes management in the UAE. EcoMENA. https://www.ecomena.org/construction-waste-uae/

Tam, V. & Le, K. (2019). Sustainable construction technologies: life-cycle assessment, Butterworth-Heinemann.

Tam, V. W. & Lu, W. (2016). Construction waste management profiles, practices, and performance: A cross-jurisdictional analysis in four countries. Sustainability, 8(2), pp. 1-16.

Tam, V. W., & Lu, W. (2016). Construction waste management profiles, practices, and performance: A cross-jurisdictional analysis in four countries. Sustainability, 8, 1-16. DOI: 10.3390/su8020190

Todorova, V. (2015). Asbestos found in new buildings in Dubai and Abu Dhabi despite ban., The National [online]. [Accessed on 23 January 2020]. Available at: https://www.thenational.ae/uae/asbestos-found-in-new-buildings-in-dubai-and-abu-dhabi-despite-ban-1.25954

Turkyilmaz, A. (2019). A comprehensive construction and demolition waste management model using PESTEL and 3R for construction companies operating in Central Asia. Sustainability, 11(1593), pp. 1-16.

UAE recycles 5 million tonnes of scrap metal annually. (2019). GoGreen [online]. [Access on 1 March 2020]. Available at: https://www.gogreen.ae/greenstory_view.php?storyid=1815

Udawatta, N., Zuo, J, Chiveralls, K., & Zillante, G. (2015). Waste management practices in construction projects: Perceptions of project managers. Conference: Unmaking Waste 2015 Conference. Adelaide, South Australia. https://www.researchgate.net/publication/280240201_Waste_Management_Practices_in_Construction_Projects_Perceptions_of_Project_Managers

Udeaja, C., Ekundayo, D., Zhou, L. & Perera, S. (2013). 'Material waste in the construction industry: a review of the legislative and supply chain issues, in Reuse of by products and materials in the construction industry'. Available at: http://usir.salford.ac.uk/id/eprint/39321/1/MaterialWaste3-Draft.pdf [Accessed 10 November 2020]

Yılmaz, M. & Bakış, A. (2015). Sustainability in Construction Sector. Procedia - Social and Behavioral Sciences, vol. 195, pp. 2253-2262. [Accessed 15 March 2020].

Zakaria, S. (2018). Go drastic on plastic waste in UAE, Khaleej Times [online]. Access on 1 March 2020]. Available at: https://www.khaleejtimes.com/nation/dubai/go-drastic-on-plastic-in-uae

Zero Waste Scotland (2016). 'Best practice guide to improving waste management on construction sites'. Available at: https://www.zerowastescotland.org.uk/sites/default/files/Improving%20waste%20manag

ement%20on%20construction%20site%20–%20best%20practice%20guide_0.pdf

[Accessed 10 November 2020]