Waste Management in Green Building Operations Using GSCM

Hatice Camgöz Akdağ[#1], Tuğçe Beldek[#2]

[#] *Management Faculty, Management Engineering Department, Istanbul Technical University*
Macka, Istanbul 34367, Turkey
[1]camgozakdag@itu.edu.tr
[2]beldek@itu.edu.tr

***Abstract*— Green buildings also known as green construction or sustainable building are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. Today the environmental issues and the concern for sustainability is encouraging more effective and efficient usage of energy, water and material currently used, ensure the prevention of any kind of waste, perform environmentally sensible and eco-friendly building design and be environmentally friendly in the process of construction. Environmental problems and the growth of construction industry cause a new topic to manage construction waste with the help of green supply chain management (GSCM). This requires close cooperation of the design team, the architects, the engineers, and the client at all project stages. GSCM reduces energy usage and waste, so it prevents any problem that will occur in human health and environment. This paper aims to combine the architects green building operations together with the engineers green supply chain management for both reducing the usage of materials, encouraging more effective and efficient usage of energy, water and material currently used, ensure the prevention of any kind of waste, perform environmentally sensible and eco-friendly building design and to be able to reuse, recycle, or recover the waste. The European Union Council published a waste management directive in 2008 that gives some goal numbers to manage construction waste to minimize the environmental effect. The goal is to reach a reduction of 70% of construction and demolition waste (CDW) that will be reused, recycled or recovered in 2020. The aim of this paper is to explore the cost-benefit and social-benefit reflections by the combination of these two techniques, based on the literature review and case study examples from Turkey a model is built and propositions regarding Green Building operations using GSCM and reverse logistics are formulated.**

***Keywords*—** *Green supply chain management, construction waste management, green building design, green building operations, waste management directives*

International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

1. Introduction

Today growing industries are causing pollution that affect our lives directly. It gives harm to our health and is a big threat for the next generation. In this case green products and services are becoming more popular. Production systems are being customer focused to meet their requirements on time, with high quality. Even in construction industry, it is important to manage every step, beginning with the building design to the demolition. The consideration must not just be with the aesthetics or the usage of the building the resource efficiency must also be reached. As a solution, green building design reduces usage of raw materials at the initial stage, which will result in a higher percentage of recyclable materials for a sustainable structure. If the design phase considered, architectures and civil engineers are the only ones who has a role in making a building "green". However, when the whole construction industry is considered, all suppliers and other subcontractors are included in the whole supply chain. For this reason, to make the total production line sustainable, green supply chain models will be useful to connect every step to each other with every kind of actors in the supply chain.

As a new topic, GSCM produces sustainable systems with the help of waste management directives. Both European Union and Turkey published regulations to manage construction and demolition waste. First aim is to reduce the raw material in the source and if it cannot be reduced, than the second aim is to recover those materials as much as it can be. To be able to reduce the raw material such as the materials that are directly used in the structure, water and energy resources a green building ca be designed at the initial stage. It is

possible to get a green building certificate with the required properties. These properties will be explained in the following sections in detail.

This paper is the further study of a master thesis, which is only comparing the CWM, within GSCM, between EU countries and Turkey. First, a current supply chain model will be defined. Next, a new model will be developed including the integration of green building design operations with GSCM will be developed. The new model will have a broad effect on providing sustainability.

2. Literature Review

2.1 Green supply chain management (GSCM)

Supply chain management definition changes day by day according to its broadening scope [1]. SCM includes logistics and trade while operating both customers and suppliers [2]. Supply chain is a cycle that starts from suppliers and ends at customers as the product or service flow [3]. Another definition is that supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer [4]. Supply chain traditionally starts from the cradle to the grave, which means from raw material state until the end product reaching the customer. However today environmental issues force processes to change and comes up with new operations such as recovery options. For this reason, closed loop supply chain, a new definition, allows the finished good collected from customers, which are end-of-life products now, and go in to some other processes for recovering them [5]. The aim of the end-of-life recovery options are to recover material, energy and avoid landfill. This recovery is a value that if it is managed properly, high profits will be gain for both producers and customers [6].

Today companies are aware of their responsibilities about the environment depending on regulations. This leads to sustainable systems that will continue their processes without giving any harm to the environment. Environmental issues are seen at every step of supply chain that starts from getting the raw material and ends with reuse or recycle or disposal [7]. This causes a requirement for companies to have a green supply chain management (GSCM). GSCM is working as a catalyst to gain competitive advantage and sustainability; with environmental consciousness and globalization [20]. A study in India, found that there are different pressures for different sectors to be able to adopt GSCM in their own traditional supply chains [8]. On the other hand it is clear that the underlying attributes of construction sectors are similar across countries, significant insights on "greening" the sector for practitioners and policymakers elsewhere in the world, which are in a similar position, i.e. witnessing significant construction growth and facing associated environmental concerns [21]. To integrate GSCM to a company five different applications can be used as environmental management systems, green purchasing and design, investment recovery and strong relations with customers [7]. In common, green activities and sustainability have an intersection in practice, which is 4R: reduction, redesign, reuse and remanufacture [2].

2.2 Construction waste management

Constructions cause air, water and noise pollution and today with global warming environmental issues became very important. Even in construction design, green materials are being preferred to minimize waste and construction firms are starting to use green supply chain management to make their work sustainable. Green buildings, sustainable design and constructions, construction waste management are some of the sustainability topics that are being used by producers [9]. The best way to minimize the construction waste generation is to disposal. In addition, material types has to be selected very carefully to get rid of recycling limitations that means recyclable materials should be preferred [10].

With different stages in construction, it is possible to define and measure construction and demolition waste. In the first half of the life cycle, CDW type can be defined. The first half is where the concept and the design phase including selecting suitable materials for the construction. However, in the second half of the life cycle the CDW amount is measured. At the last stage, after decomposition the materials are seen clearly at the demolition stage.

To leave a healthy environment with high level of social, economic and environmental conditions to future generations, sustainability is important which leads to improved quality of systems [11]. Supply chain management has four specific roles in construction; improving the interface between site activities and the supply chain, improving the supply chain, transferring activities from the site to the supply chain, integration of site and supply chain. An improved SCM helps to understand

construction problems and shows a direction to solve them even in a specific situation like construction [12].

2.3 Green building design

CWM is not the only way to reduce pollution and other bad effects occurring in the environment. Like any other industries, green production is very popular today at construction sites. At the design phase, architectures are considering different types of shapes and materials to provide energy saving. Green building design provides savings in different scopes such as; nearly 30% energy, 35% carbon, 30-50% water usage, 50-90% [13]. Figure 1 shows the importance of the reason for building green structures according to different locations ("World Green Building Trends Smart Market Report" published in 2013).

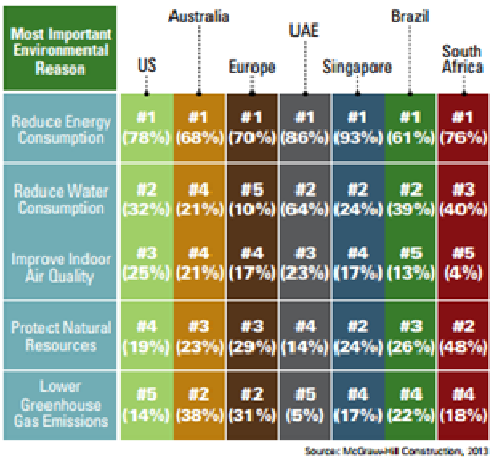

Figure 1. Most important environmental reason for building green by locations

There are different definitions for green building in the literature. A green building is a better designed than a traditional building in case of its effect to the environment. Another definition is the building that provides an important development and innovation within its environment. Green building is not only the consumer but also a manufacturer of energy and water. During its life cycle, it presents the healthiest environment while using water, energy and land sources efficiently [14].

3. Analysis of CWM in Turkey and European Union Countries

3.1 Waste management principles related to Turkish and EU Council directives

The regulations of common waste management at Turkey are set according to the waste variation. In Turkey EU directives and country-based guidelines are published and put into practice. In this scope, different types of waste are being stored regularly such as domestic solid waste, excavation soil, construction and demolition waste, waste batteries and accumulators, hazardous waste, herbal waste oils, medical waste, end-of-life tires, packaging waste, polychlorinated biphenyl and polychlorinated terphenyl, waste electrical and electronic equipment, waste oil, end-of-life vehicles, maintenance and repairment equipment of vehicles [15].

One of the most important principles of Turkey's waste management strategy is to prevent waste at source, otherwise reduce waste and finally if waste is unavoidable recycle it. The Ministry of Environment and Urban Planning is maintaining the all collected terms related to waste management directive under a common structure, simplifying regulations and adjusting them according to the EU waste management directive updates.

There are two issues on recycling in the 10th development plan for years 2014-2018:

- Industries will give attention to applications such as recycling and recovery.

- Recycling performance is negatively affected by some topics such as lack of knowledge about recycling benefits, which is one of the important issues in the solid waste management, lack of standardization of the recovered secondary products, deficiency of incentives and orientation system.

According to the national data about recycling; at 2003, at 46 recovery centers nearly 4 thousand people were employed and as a result of recovery operations 62 million TL added value provided. At 2011, at 898 recovery facility nearly 60 thousand people were employed and as a result of recovery operations the provided added value exceeded 1 billion TL [15].

The law "Regulation on Excavation Soil, Construction and Ruin Waste Control", which is in force, was promulgated at 18.03.2004. Following goals are given in the regulation: Reduce excavation, construction and ruin waste without giving harm to the environment at the place where they are produced, collect, store temporarily, transport, recover, use and dispose them.

Firstly, to reduce excavation soil and construction/demolition waste at source, reuse, collecting separately, recovery and especially evaluating as infrastructure material are essentials. Also not mixing excavation soil and construction/demolition waste is essential. To make a good system for recycling and removing is

important by separating waste at the source and making “selective destruction”.

Recovered products, with respect to the standards, are used with original materials or separately at new concrete production, road, parking lot, pavement, walking roads, drainage works, sewer pipe and as filling material at cable laying, lower and upper building construction, sports and game centers construction and other filling and recreation works primarily. Construction / demolition waste which, cannot be recovered are used as daily covering material in storage areas after required separation and sizing.

Permitting authority is given to the city and district municipalities in the urban area, metropolitan municipalities in metropolitans and district municipalities for which cities are not metropolis [15].

Waste generation is increasing day by day at many countries due to the growth of towns and cities. Many regulations about construction and demolition waste management are developed to prevent the environment [16].

Directive 2008/98/EC starts with waste, recycling and recovery definitions. It also explains how waste is classified as a secondary material or product. The aim of the waste management is protecting the environment without giving harm to human health, animals or plants, water, air and soil.

Construction and demolition waste (CDW) generated in European Union is nearly 30% of total waste. CDW includes many kind of recyclable material such as excavation soil, metals, asbestos, plastics and so on [17].

Directive 2008/98/EC gives a strict goal for construction and demolition waste that by 2020, 70% of construction weight has to be recovered. Size or type of the construction does not make any difference for this goal, as every project must reach it in 5 years. It seems to be strict but it is very important to manage those CDW to protect human health and the environment.

In terms of waste management, European Union has published a directive (2008/98/EC) which gives details about goals for EU countries according to different types of waste. After giving the definition of waste, to standardize waste management at EU countries, the directive mentions the objectives as follows:

“In order to comply with the objectives of this Directive, and move towards a European recycling society with a high level of resource efficiency, Member States shall take the necessary measures designed to achieve the following targets:

(a) by 2020, the preparing for re-use and the recycling of waste materials such as at least paper, metal, plastic and glass from households and possibly from other origins as far as these waste streams are similar to waste from households, shall be increased to a minimum of overall 50 % by weight;

(b) by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70 % by weight.” [18].

Turkey is not a member of EU but as a candidate, ministries are trying to edit regulations according to the EU standards. In 2008, ministry of environment and forestry published a waste management action plan that includes 4 years for each cities in Turkey. It stated goals for cities to manage solid and hazardous waste types in order to protect environment and human health.

There is no goal like gaining 70% of materials with recycling at 2020, stated in the EU Directive, for Turkey in the related regulation. Every year in Turkey, 125 million tons of excavation soil is evaluated and regained. At the current situation construction and demolition waste amount is nearly 4-5 million tons per year. With the new regulation of rehabilitation of areas that are under risk of disasters for the first 3 years, annual goal will be 40% that is 10 million tons/year and 6 million tons/year for regaining materials [15].

3.2 Current supply chain models

Istanbul Metropolitan Municipality Directorate of Environmental Protection manages construction and demolition waste according to the Turkish regulation. First, contractor defines the waste amount of the construction or demolition and applies to the district municipality with a 70 TL valued receipt to get acceptance form while showing the construction/demolition license. This form must be filled by the contractor who is the producer of the construction (or demolition), transporter (logistics firm) and storage firm. Trucks that will carry CDW must register to the “Vehicle Tracking System (VTS)” and the firm must get the transportation license. VTS is not included in the regulation but it is active according to the act of the parliament. Only vehicles registered to the VTS can get the transportation license from Istanbul Metropolitan Municipality Directorate of Environmental Protection. Trucks which have lift system will be registered to the VTS and they have to be yellow, on their sides there cannot be any

kind of symbols and also the license plate and "excavation soil and construction and demolition waste transporter" must be written on both sides of the truck. In the regulation, it mentions about containers that will be in front of the construction (or demolition) site but in practice there are dumper trucks instead of containers for waste.

Today construction firms in Turkey usually use subcontractors to transport CDW to storage areas. They have to take permission from municipalities to send their waste to the pre-defined areas according to the capacity of the landfill. In Istanbul, ISTAC is the only company that manages landfills and recycling operations in construction industry. ISTAC is an affiliate of Istanbul Metropolitan Municipality, which works according to the national and international standards [16].

Figure 2 shows current supply chain model for a construction firm in Turkey. In this model firm sends CDW to the landfill and the process finishes. This means that firm does not get any profit from their own waste as well as that waste may give harm to the environment if they are stored at a landfill.

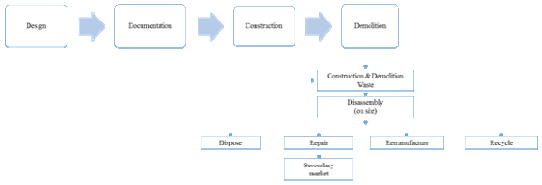

Figure 2. Current Supply Chain Model for a Construction firm in Turkey

Annual construction and demolition waste amount shown at Table 1 retrieved from Istanbul Metropolitan Municipality Directorate of Environmental Protection is as follows [17].

Table 1. Annual excavation soil and CDW amounts that are disposed or recovered, and administrative sanctions

	Unit	2010	2011	2012	2013	2014	Total
Disposed excavation soil amount	Thousand tons	24.100	47.709	52.455	65.502	69.999	259.765
Disposed CDW amount	Tons	5.361	5.680	5.152	0	0	20.451
Recovered excavation soil amount	Thousand tons	34	36	284	280	221	855
Recovered CDW amount	Tons	73.200	116.952	15.695	14.312	0	220.159
Administrative sanction	Piece	1.482	887	716	439	320	3.844
	Million TL	55	45	29	30	26	185

It is difficult to manage construction and demolition waste in EU because of strict goals mentioned above. A study showed that Southern Europe countries need development in their measures, and Central and Northern countries need new models to integrate waste management technologies locally, so that waste management systems will work efficiently to be able to reach those governmental goals [18]. A construction and demolition waste management regulation published in Spain and tested in the Seville area. Figure 3 shows the closed loop system known as Alcores model for waste management. This system allows construction and demolition waste to be checked and operated and also recycled [17].

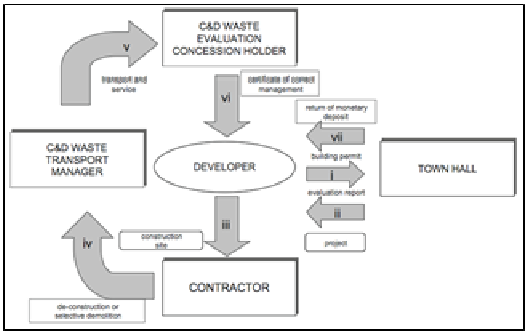

Figure 3. Construction and demolition waste management model used in Spain

This example shows a great auto-control for a firm in Spain. They operate every supply chain management steps, and after transportation they again check the validity if the management tools are used properly or not.

4. Discussion

4.1 Integrating green building design to GSCM

In order to reach the waste management goals the raw materials used in the structure body of the construction must be reduced by using GSCM. It is hard to make the balance between the strength and the amount of the material at the design phase according to different material types. It is possible to use "green" materials while reducing the amount and make the structure as strong as it was with the traditional materials. There are new type of materials that can be use as substitutes. With the advantage of being light and durable, they are also recyclable and connected to GSCM. A closed loop sustainable system design leads a manufacturer to use waste materials in another construction project with second quality materials. In order to be able to reach the regulation goals in both Turkey and EU, waste amount not only has to be reduced but most of them must also be recovered at the end of the life cycle. Green building will already help the reduction of the materials and will provide energy saving.

It is hard to implement a new system in a whole project. For this reason, architectures should think of the green building principles at the beginning of the design phase. Both green building design and

GSCM will result with the economic and social benefits while fitting the governmental requirements.

4.2 Developed supply chain model

A closed loop supply chain will be sustainable for construction industry that will also suit the definition of green supply chain management explained above. The following model will reduce the disposal amount of waste material with the help of recycle, repair and remanufacture operations.

Figure 4 shows the developed supply chain model, with green building design integration, for a construction firm in Turkey. By this model, construction firm will be able to sell their recovered materials to the secondary markets and get profit from them. In the current model, firm had no information on what is happening to their waste after sending them to the landfill. Thus, this new model will be sustainable for the environment as the materials will not be left on the ground and will not give harm to the environment. Also at the beginning of the design phase, raw material usage will be minimum according to green building principles. Usage of recyclable materials will be increased and energy efficiency technology will be preferred.

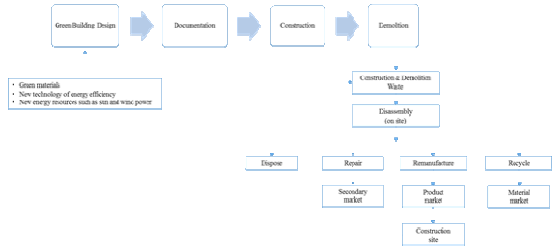

Figure 2. Developed supply chain model with green building design integration

Today so many different standards for green building design is being used. With the requirements of green building, architectures and civil engineers try to provide those items at the beginning of the design phase. If the owner of that building, as a team, supplies every need for a green building than they can get a certificate. Even in the construction site it is very obvious that green building construction does not make any pollution. They use green materials while cleaning the environment with new kind of technologies. Air conditioning systems are designed at the beginning of the construction when the building is a concrete frame already. Design of the windows, doors and the whole structure of the building is proper for energy resources. With this detailed plan the green supply chain management starts. Documentation phase is done with the help of third party companies, which provides green building certification. They have some standards that continues for a specific time-period and they do some audits to make the system sustainable. After all, construction of a green building is for energy efficiency and prevention of every kind of pollution. Every building has a life cycle similar to the product life cycle. End-of-life buildings/products has to be recovered or disposed. For buildings, demolition and disassembly phase starts at the construction site. For valuable materials, within a closed loop supply chain, the materials can be sold at the secondary market. If those materials are able to be recovered with different options such as recycling, remanufacturing or repairing, than the firm which owns that construction can use those materials as a low quality filling material etc. Green buildings provide recoverable not disposable "green" materials.

This developed supply chain model integrates green building design operations to green supply chain so that it fits each other very suitably. The first aim of waste management directives is to reduce the raw material used in the construction. This aim is reach with green building standards. In addition, recyclable materials has to be used as a need of green building design, which we want it at the end of the demolition of the building in the green supply chain. With these benefits, integration of green building design to GSCM is very appropriate for both companies and the native population.

5. Conclusions and recommendations

The aim of this paper is to explore the cost-benefit and social-benefit reflections by the combination of GSCM and green building design. Based on the literature review and case study examples from Turkey a model is built and propositions regarding Green Building operations using GSCM and reverse logistics are formulated. A green supply chain management flow chart is established to understand the CDW management system clearly in Turkey. To conclude this study, there are some numerical differences between the regulations of Turkey and European Union. As there are no target numbers in the excavation soil, construction, and demolition waste management regulations for Turkey, the construction firms has no idea of what is the consequences of the waste sent to the landfill.

To make the supply chain sustainable, in the design phase of a construction, the less and green materials may be preferred. As mentioned in the regulations first aim has to be to reduce waste, by

using less raw materials if possible. This development provides "green building design" principles at the beginning of the construction project.

After reducing waste, the next step is to do recovery operations for the CDW. If the construction firm will be responsible for the waste and if they can make their supply chain closed, they will also be able to re-use those secondary raw materials and remanufactured products in their own site.

The other alternative is to sell those secondary materials to the market. At future studies, customer points can be added to sell the recovered products that the firm will not use them on their site or remaining products.

For further research, a capacitated linear mathematical model, including multi-product, multi-recovery and multi-manufacturing options, can be developed for a construction firm, which the firm will be able to use their own recovered products at their own construction sites. Finally, it can be said that if these above mentioned improvements are applied as integrating green building design to GSCM, setting a supply chain for construction industry, the system will be sustainable and the construction firm will be able to minimize the cost while making profit from their own waste.

References

[1] Parkhi, S., Joshi, S., Gupta, S., & Sharma, M. (2015). A Study of Evolution and Future of Supply Chain Management. Supply Chain Management, 9(2), 95-106.

[2] Wang H., Gupta S., (2011) Green Supply Chain Management, Product Life cycle approach, McGraw Hill.

[3] Bachok, S., Khuzzan, S.M.S., Jaafar, S. and Baharudin, H. (2004) 'Construction Supply Chain Management and Coordinated Design Drawings: An outlook of the construction industry and sustainable urban planning' In: 9th International Symposition on Planning & IT, Vienna, Februray, pp. 67-84.

[4] Christopher, Martin L., (1992) Logistics and Supply Chain Management. London: Pitman Publishing.

[5] Beamon, B. M. (1999). Designing the green supply chain. Logistics information management, 12(4), 332-342.

[6] Guide, V. D. R., & Van Wassenhove, L. N. (2000). Closed-loop supply chains. WORKING PAPERS-INSEAD R AND D.

[7] Zhu, Q. and Sarkis, J. (2006). An inter-sectoral comparison of green supply chain management in China: drivers and practices. Journal of Cleaner Production, 14(5), 472-486.

[8] Xu, L., Mathiyazhagan, K., Govindan, K., Haq, A. N., Ramachandran, N. V., & Ashokkumar, A. (2013). Multiple comparative studies of green supply chain management: pressures analysis. Resources, Conservation and Recycling, 78, 26-35.

[9] Yuan, H. (2012). A model for evaluating the social performance of construction waste management. Waste management, 32(6), 1218-1228.

[10] Begum, R. A., Siwar, C., Pereira, J. J., & Jaafar, A. H. (2006). A benefit–cost analysis on the economic feasibility of construction waste minimisation: the case of Malaysia. Resources, Conservation and Recycling, 48(1), 86-98.

[11] Ortiz, O., Castells, F., & Sonnemann, G. (2009). Sustainability in the construction industry: A review of recent developments based on LCA.Construction and Building Materials, 23(1), 28-39.

[12] Vrijhoef R., Koskela L., (2000) "The four roles of supply chain management in construction", European Journal of Purchasing & Supply Management, 6, 169-178.

[13] Council, U. G. B. (2001). Leadership in energy and environmental design (LEED).

[14] Terekli, G., Özkan, O., & BAYIN, G. (2013). Çevre dostu hastaneler: Hastaneden yeşil hastaneye.

[15] Ulusal Geri Dönüşüm Strateji Belgesi Ve Eylem Plani 2014-2017, ÇŞB, 2012-1

[16] Istanbul Metropolitan Municipality Directorate of Environmental Protection, personal communication, April 20, 2015.

[17] Solís-Guzmán J., Marrero M., Montes-Delgado M. V., Ramírez-de-Arellano A., (2009) A Spanish model for quantification and management of construction waste, Waste Management 29, p. 2542–2548.

[18] Pires A., Martinho G., Chang N., (2011) "Solid waste management in European countries: A review of systems analysis techniques", Journal of Environmental Management, 92, 1033-1050.

[19] Directive 2008/98/Ec Of The European Parliament And Of The Council of 19 November 2008.

[20] Chowdhury, M., Upadhyay, A., Briggs, A., & Belal, M. (2016). An overview of green supply chain management practices in Bangladesh construction industries 1-10.

[21] Balasubramanian, S., & Shukla, V. (2017). Green supply chain management: an empirical investigation on the construction sector. *Supply Chain Management: An International Journal*, *22*(1).