

## ANALYSIS OF THE BENEFITS OF CREATING AN EFFICIENT GREEN SUPPLY CHAIN IN AGGREGATE EXTRACTION

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**ABSTRACT.** Creating a green supply chain in an organisation operating in conditions of uncertainty and constant change is key to improving its competitiveness. This is also an important organisational step that would reduce the risks to the environment, as well as to human life and health. It is therefore important to pre-determine the current and future benefits of this supply chain. In view of the growing potential for environmental degradation in aggregates extraction, it is crucial that all stakeholders find the benefits of setting up a green supply chain. In this context, a number of organisations invest in various initiatives leading to improvements in processes and activities in order to increase the benefits in the implementation of production processes. Thus, achieving sustainable development is becoming a key factor in the present moment, which helps organisations to focus on creating benefits for people, for the planet, and for themselves in the form of profit.

**Key words:** integrated supply chain management, green supply chain, business performance.

### АНАЛИЗ НА ПОЛЗИТЕ ОТ СЪЗДАВАНЕТО НА ЕФЕКТИВНА „ЗЕЛЕНА“ ВЕРИГА НА ДОСТАВКИ ВЕРИГА ПРИ ДОБИВА НА ИНЕРТНИ МАТЕРИАЛИ

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**РЕЗЮМЕ.** Създаването на „зелена“ верига на доставки в една организация, работеща в условията на несигурност и постоянни промени, е от ключово значение за подобряване на нейната конкурентоспособност. Това е също така и важна организационна стъпка, която би довела до намаляване на рисковете както за околната среда, така и за живота и здравето на хората. Ето защо е важно предварително да бъдат определени настоящите и бъдещи ползи от тази верига на доставки. С оглед нарастващите възможности за влошаване състоянието на околната среда при добив на инертни материали е изключително важно всички заинтересовани страни да открият ползи от създаването на „зелена“ снабдителна верига. В този контекст редица организации инвестират в различни инициативи, водещи до подобрения на процеси и дейности с цел увеличаване на ползите при реализиране на производствените процеси. Така постигането на устойчиво развитие се превръща в ключов фактор в настоящият момент, които помага на организацията да се фокусира на създаване на ползи за хората, планетата и за себе си под формата на печалба.

**Ключови думи:** интегрирано управление на веригата на доставки, „зелена“ верига на доставки, бизнес представяне.

### Introduction

In the past few years, environmental pollution has been one of the major global problems that could have catastrophic consequences for human life. Of the several types of pollution affecting the elements of the environment, the deterioration of air quality is the one which requires immediate improvement measures. Global warming due to increased greenhouse gases and rising levels of fine dust particles are some of the most serious problems.

The amount of carbon dioxide, which was found to be approximately 280 parts per million before the Industrial Revolution, has reached a proportion of 380 parts per million and has accelerated. It has been found that increasing the proportions of carbon dioxide to more than 450 parts per million will increase the temperature to 2 degrees Celsius, which will lead to faster and irreversible melting of the ice of Greenland and Antarctica. Elevated atmospheric temperature by 2 degrees Celsius will lead to increased energy consumption to achieve and maintain the temperature of human comfort. The melting of ice in Greenland is expected to

raise sea levels by 23 feet, which means that the face of the earth will be changed beyond recognition. Without proper action, it will be simply impossible to stop at 450 ppm. For this to happen, global changes in supply chains are needed that are linked to the introduction of a number of "green" practices. (McKibben, 2007; Ho et al., 2009).

In the past 200 years, the concentration of carbon dioxide in the atmosphere has increased by more than 33%. The most accurate and complete data on CO<sub>2</sub> concentrations date back to 1958, when constant instrumental measurements began on Mount Mauna Loa in Hawaii, and they show a steady increase in its concentration. If at the beginning of these measurements, the concentration was 315 parts per million (ppm), then at the beginning of our century, it was 370 ppm, and in 2019 it was already 408 ppm. (<https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html>)

According to the World Health Organisation (WHO), 91% of the world's population is exposed to annual concentrations of particulate matter (PM)<sub>2.5</sub>, which exceed the norms recommended by the WHO. PM<sub>2.5</sub> includes contaminants

such as sulphate, nitrates, and carbon black. They penetrate the lungs and cardiovascular system and can be a high risk to human health. (<https://www.who.int/data/gho/data/themes/air-pollution>).

Regarding particulate matter, the Republic of Bulgaria is ranked 72<sup>nd</sup> in the ranking of countries with the most polluted air as of 05.2022 according to a study presented through the AirVisual Platform. (<https://www.iqair.com/world-air-quality-ranking>).

Statistics shows only a small proportion of air pollutants. Therefore, the benefits of building green supply chains in the sector would also significantly improve people's quality of life. The increase in the demand for aggregates in recent years has also increased the investment interest in the deposits of aggregates - gravel and deposits for the extraction of crushed stone fractions.

In 2020 alone, a total of 28 514 471 335 kg. of crushed stone, gravel, debris, and dust from rock materials were sold, according to data from the National Statistical Institute. (<https://nsi.bg/bg/content/12271>)

The intensive development of extractive activities related to aggregates leads to a reduction of natural resources and accelerated search for space for their storage, as well as to changes in the supply chain in the context of sustainable consumption. For decades, the extraction and transportation of these materials has created a series of negative effects on the environment. The existence of positive change should be linked to the introduction of innovative "green" practices and the distribution of responsibilities among all actors in the chain. Thus, the benefits and efforts for the implementation of environmentally friendly activities, as well as increasing the productivity of machinery and equipment will be consistently distributed. Based on the principles of sustainable development, this study examines the possible benefits of setting up green supply chains and their impact on key performance in the sector.

The design of the activities themselves in the chain connects the individual components that meet the conditions for achieving sustainable development and economic efficiency. As the characteristics of the activities have a strong impact on the reduction and elimination of waste, pollution, noise, and others in this development, a set of proposals for areas of future research is presented. They should look for empirical evidence of the link between the elements of the supply chain, the aspects of the green deal, and the economic performance. Such a key connection can be related to the possibility of integrated management, high added value of key operations, flexibility of the people involved in the chain, and others.

## Defining a "green" supply chain

The establishment of a green supply chain is one of the best strategies for achieving sustainable development, reducing carbon emissions and dust, as activities are aimed at improving key environmental indicators. Dynamic changes on a global scale oblige organisations to look for opportunities to improve processes that have an impact, especially on the environmental and social environment. Therefore, the "green" supply chain is considered to be an innovative approach whose effectiveness is measured by improving the productivity of products and processes, taking into account the

requirements of environmental standards adopted by relevant legislation. The key goal is to reduce waste and prevent the dispersion of harmful materials in the environment during all phases of the product life cycle.

According to one of the most commonly used definitions, green supply chain management is: "the process of using environmentally friendly raw materials and turning them into products that could be regenerated and reused at the end of their life cycle, thus creating a sustainable supply chain" (<https://www.mhi.org/media/news/7056>)

The modern "green" supply chain includes all the processes and operations performed by the participants. The beginning is set with the emergence of the concept of the product, its design, the selection of raw materials and suppliers, transport equipment, production processes, distribution channels, and disposal after the end of its life cycle. Environmental impacts should be kept to a minimum, with an emphasis on the optimal use of resources to create an environmentally friendly supply chain.

Another key point is to successfully integrate modern environmental management practices throughout the supply chain in order to achieve sustainable development that becomes a strong competitive advantage. This view was reflected in Srivastava's research back in 2007, wherein the "green" supply chain was defined as: "the integration of environmental thinking in supply chain management, including product design, supply and choice of materials, production processes, supply of the final product to consumers, as well as activities at the end of the life cycle of the product after its useful life". (Srivastva, 2007).

## Integration of "green" practices in the extraction of aggregates

The key objectives for sustainability in the supply chain are usually related to the availability of environmentally friendly and energy efficient operations, reducing the use of rare (scarce) resources, and recycling end-of-life products. An effective way to do this is to integrate good supply chain sustainability practices. A number of examples of sustainable extraction, processing, sorting, and transport of a number of resources are well known, including aggregates, which are widely used in various conventional production operations (housing, road network, railway infrastructure, cement production, etc.).

In addition, there are more complex ways to restore not only the material value of resources that would improve production operations (energy, labour, catalysts, fuel, etc.). These recovery forms include reuse at the level of components and parts in the form of spare parts for used machinery and equipment. The management of these supply chains contributes to the sustainability of the environment by reducing emissions and the consumption of non-renewable resources and energy. The economic effect of such activities is obtained mainly by reducing the cost of supply and processing of spare parts. Social sustainability is improved by achieving a safe and healthy living environment and increasing people's well-being.

The integration of "green" aggregate extraction practices is key to efficiency in three main processes: extraction (providing the right volume of output with the required quality), repair (repairing defective parts for reuse), and merging practices / experiences with other actors in the chain.

Extraction processes provide information to improve repair processes, such as quantities, structure, sorting, and quality classification of extracted materials. Extraction information can be at the level of products (quality), machinery (repair), components (recycling), materials (renovation), people (qualification), etc. depending on the quality required by customers in the relevant markets. The effective implementation of greening practices depends to a large extent on the needs of the clients and the legal norms for the respective regions of work. Repair, in turn, also includes many complex operations: disassembly of component modules, cleaning, inspection and adjustment, replacement of components, reassembly and commissioning. The processing of parts and components for reuse is considered to be component-level recovery in which the components are cleaned, reworked, and inspected strictly to achieve quality characteristics as newly-manufactured. Refurbished components can be used as spare parts, in repaired or resold machines. This category of "green" practices also includes parts / components or machines that are in working order but no longer meet the needs of an organisation. These machines or modules should be repaired and resold on the secondary market or disassembled into components to be used for after-sales services, such as mining. For end-of-life machines and equipment that have exceeded their economic or technical life, detail-level recycling is the only effective option. A key element in the repair process is that remanufactured parts, modules or machines that can be reused are integrated into the supply chain or another used by the organisation. Therefore, it is essential that the organisation has access to information about the needs of such machines / materials / components / modules in different markets worldwide.

According to the research presented above, the integration of "green" practices has a significant positive impact on the three main components related to achieving sustainable development: environmental, social, and economic. From an organisational point of view, however, the economic component is more used, which is associated with achieving greater financial gains. Effective management of an organisation in the context of green supply chains should achieve three key benefits related to sustainable development. In the first place are the environmental benefits of reducing the carbon footprint, dust particles, and proactive compliance with the law. In the second place are the benefits for the client from improving their satisfaction and attitude. In the third place are the informational benefits of integrating good green practices among all actors in the supply chain.

### **Key benefits of setting up a green supply chain**

This section will present several key benefits for organisations working in the aggregates sector from building a green supply chain.

The establishment of a sustainable supply chain in the sector in question depends to a large extent on the source of the extracted materials. Here, efforts are focused on identifying all opportunities to reduce direct costs that would lead to improved activities. Strategies for optimal extraction, machine repair, renewal, reuse, etc. are applied, and some of the machines can be reused in some way in the same or alternative supply chain. For example, recovered components or modules could be marketed for secondary use to generate

additional revenue. Others may be used inside the chain instead of new ones to reduce delivery time and costs. Vehicles and machines that meet the highest environmental standards are fast becoming a competitive advantage over those with lower performance. Managers' awareness of the high benefits of built-in value in renewable components and their reuse in various ways is part of modern management leading to sustainable development. For example, creating a program to recycle own and similar components and return them to working order is just one way to reduce the use of "fresh" raw materials by using recovered parts. Defective or high-cost defects, on the other hand, are sent for recycling to suitable places. In managing the green supply chain, managers coordinate the replacement of primary parts and modules with remanufactured components or materials, which could lead to significant savings in energy, water, and other resources. In addition, these activities lead to minimisation of waste, landfill and treatment costs, as well as various sanctions for violating environmental regulations. All the financial and other sector-specific advantages of building a green supply chain mentioned so far and other specific ones should be systematised into three main benefits, which could become strong competitive advantages. Some of the components of these benefits may not imply immediate financial value, but they can also increase the organisation's competitive advantage and ultimately lead to financial improvement in the long run.

The environmental benefits considered relate mainly to activities in two key processes that have an impact on the environment: carbon footprint / dust particles and a green public image. A number of regulations in this area have been adopted in recent decades, namely: the Directive on the Management of Waste from Extractive Industries (2006/21 / EC); The Environmental Liability Directive (2004/35 / EC), etc. They all hold organisations in the sector responsible for the proper conduct of extraction and transport activities. These regulations require the achievement of mandatory norms and goals, which over time become more stringent. Managers should take a proactive stance in this regard, ensuring compliance with legal regulations. One possibility is to implement a set of "green" measures aimed at tackling environmental problems by including in the price of aggregates some of the environmental costs associated with the extraction of aggregates, such as noise, dust, deterioration of appearance, and loss of biodiversity. Another possibility is to encourage and/or redirect demand from purposefully extracted aggregates to alternatives, such as recycled aggregates. The use of recycled aggregates, although it also has its costs for environmental protection in the form of energy consumption and noise generation, is an important aspect of reducing the environmental costs associated with extracting materials from the earth's interior (as long-term impacts on biodiversity). For example, the use of recycled materials does not interfere with new terrain or the seabed. Organisations that take steps to implement green practices before the legislature would be able to lobby for certain rules and regulations in line with their practices. In this way, they get the opportunity to provide themselves and the sector with a good image and public support in drafting legislative measures. In addition, with the advantage of being first on the market, they could gain experience in operations related to environmental standards and thus gain more market share. A good example of this is the creation of an electronic platform by several large

organisations working in the sector, which can be used to connect participants in various chains for the exchange of information and current trends in international law (<http://www.bapim.org>).

In a highly competitive economic environment, improving the green image through the introduction of environmentally and socially responsible practices is an important part of the day-to-day operational activities of managers. Worldwide, a number of organisations, such as Greenpeace, Newsweek, and other voluntary initiatives, such as Global Reporting Initiative and Electronic Take Back Coalition, in various sectors of the economy publish rankings and reports on the environmental performance of large organisations. Thus, they bring to the fore activities related to reducing the harmful effects on the environment. Combined with the growing public interest in environmental issues and the growing "environmentally conscious" customer segment, these initiatives have increased the pressure on organisations worldwide. The ability to calculate, record, and communicate the reductions in carbon emissions and particulate matter resulting from green practices in the chain increases environmental benefits and becomes a powerful competitive advantage. In the Republic of Bulgaria, aggregates mining organisations comply with the Bulgarian Aggregates Producers Association (BAPMA) Ethical Code, which includes compliance with all legal regulations and requirements and the implementation of a sustainable business model aimed at caring for the social development, the environment, and the economic prosperity of the communities where the organisations operate.

The possible benefits for the client relate to the implementation of activities that would increase their satisfaction and loyalty. The use of "green" practices in the supply chain supports the development of the organisation and access to innovative practices in the field. First of all, a well-organised system for researching customer needs and assessing their attitudes could ensure their trouble-free service, as well as greatly increase their willingness to make a subsequent purchase. (Ramanathan, 2011) Similarly, the implementation of component reuse activities would increase the availability of spare parts, especially for older models whose parts are no longer manufactured or are very rarely manufactured. Improved spare part management processes will enable the organisation to reduce the use of "fresh" materials and raw materials for new components and modules. All these opportunities provided by the implementation of a "green" supply chain significantly contribute to customer satisfaction and attitude. Organisations that have started sustainable mining and processing activities and have established working channels for direct marketing are more likely to offer preferential contracts to potential customers to weed out others. This is an extremely successful tactic to negotiate different conditions with customers in the market, which should include the existence of "green" practices in terms of quality, quantity, and price of products delivered. Such contracts usually include conditions for long-term and large-scale deliveries, which are subject to special agreements for basic and ancillary services. This enables organisations to maintain mutually beneficial relationships with customers and prevent third parties from sourcing, processing, and transporting their products.

Last but not least, the informational benefits relate mainly to the sharing of valuable data on generally accepted "green" initiatives, supplies, defects / problems, machine failure rates, useful life of modules and others, customer complaints that lead to improved efficiency and effectiveness. For example, common emergencies, or conditions for sustainable and safe extraction, can be avoided in the future by other actors in the supply chain. Similarly, the creation of a database and the search for opportunities to "green" certain processes through the application of innovative practices would improve the attitude of customers and public authorities.

## **Limitations and future research**

It is important to note that the considered benefits of creating an efficient "green" supply chain are considered through a theoretical study from the point of view of producers, and refer to the value acquired by them and not by the environment or customers. In addition, the findings presented have not yet been applied and studied in real organisations. Therefore, research in the aggregates sector is forthcoming in the near future.

## **Conclusion**

The present study aims to identify effective benefits in implementing a green supply chain in order to achieve sustainability in aggregate extraction. The research approach itself has been used to identify the inter-relationships between individual factors in the green supply chain that affect competitiveness. The study of possible benefits confirms that environmental standards, green process design, and recycling are three key components that are the main reason for green practices. In addition, the adopted standards for environmental protection and safety have the strongest effect on extraction processes. Other economic and social ones contribute to sustainability, but without having a key impact. Such information will be useful for a number of managers, who should realise that for the management of the "green" supply chain they need to consider which of these components are more important and which are less important. Such categorisation of the components and their impact on the benefits presented should help in making operational and strategic decisions that will help to create a much more efficient and sustainable green supply chain. However, progress in this area needs to be constantly considered. It is therefore necessary to examine the issues raised in future research from the perspective of knowledge management and innovative technologies. Implementing appropriate management and dissemination models on the subject would increase the efficiency of the use of the green supply chain. Developing different models to study the impact of green practices on the efficiency of the aggregates business can lead to improved public confidence and competitiveness. It is obvious that suppliers, for example, play a key role in the success of such a supply chain. Therefore, the first step in this direction could be the design of a comprehensive model for choosing a "green" supplier through innovative approaches, and methods to achieve sustainable environmental goals.

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