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LITERATURE REVIEW ON SUSTAINABILITY IN MULTIMODAL TRANSPORTATION

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ABSTRACT

There has been significant growth in research on sustainability issues and intermodal transport in freight distribution since the 1990s. However, when it comes to sustainability literature in multimodal transport it seems that there are very few publications. The aim of the study is to analyze the studies that examine sustainability in multimodal transport, which is the most sustainable transportation system. Therefore, the three key phrases, “multimodal transport sustainability”, “intermodal transport sustainability”, and “combined transport sustainability” have been scanned in seven separate databases and the studies obtained have been analyzed by content analysis method. The analysis reveals that railway transportation has prominently been used in the intermodal combinations, which seems to have contributed to gaining sustainability. It is also observed through the analysis that most of the studies have used case study method to analyze the sustainability of multimodal transport activities. Still another point revealed is that the social dimension of sustainability seems to have scarcely been analyzed in the sustainable intermodal transportation literature.

Keywords: *Multimodal Transportation, Sustainability, Content Analysis*

1. INTRODUCTION

The term of sustainability born was in 1987 in the Brundtland Report as a policy concept (Kuhlman and Farrington, 2010). Sustainability has three main dimensions as environmental, social and economic (Tanzil and Beloff, 2006); however, in time, it has started to be used to refer to practices that are more environment related (Heinberg and Lerch, 2010). In addition to that, in recent years, "sustainability" concept has attracted the attention from the media, the industry and the research community because of the concerns related to global warming and this has made the concept more popular (Hakam and Solvang, 2013). Until today, one of the biggest challenges for businesses that are trying to adapt to the information age by using many methods, tools, approaches and policies, especially with the advent of the information age, has been to adapt to sustainability approaches (Nazlı, 2006). Basically, "sustainability" concept can be defined as the management of resources with a view to continue for current generation and the generations to come (Kuş, 2012). The most common and most cited definition of sustainability was made in the Brundtland Report in 1987 by the World Commission on Environment and Development, which is "Meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

In 2010, "sustainability" was announced as megatrend by Lubin and Esty. McDonagh and Prothero (2014), recognized that at world's current consumption levels the planet cannot sustain so more or its carrying capacity for humanity ad infinitum. So, the importance of sustainability issues has increased highly in the last two decades. The etymological root of the "sustainability" term is based on the word "sustenerne" (sustain) in Latin. Conceptually, it is based on forestry, fisheries and soil science and was first used in these branches of science. At the end of the 18th century, the German miner Carlowitz used it as the mining industry's masts to mean that timber plantations would be utilized in a way that would increase the productivity and sustainability (Aksoy, 2013). After that, the concept of sustainability has been associated with the renewable sources like agriculture ecology and fishery, in other words, the productivity related areas (Bozlağan, 2005). It has been described as "ability to maintain productivity despite obstacles" (Aksoy, 2013).

Sustainability concept has three dimensions which are; environmental, financial and social dimensions that are also referred as the triple bottom line of sustainability (Sislian *et al.*, 2016) or called three dimensions of sustainable development (Tanzil and Beloff, 2006). That triple bottom line is defined as 3P in several papers, standing for People, Planet and Profit. Similar to the triple bottom line of sustainability, the three dimensions of sustainable development are specified as economic growth, social progress, and stewardship of the environment (Tanzil and Beloff, 2006). Likewise, Litman (2014) also has summarized "sustainability" dimensions as economic, environmental and social. Litman has also added some sub-dimensions to those three main dimensions. The three main dimensions and their sub-dimensions are given in Table 1. Litman claims that a system must contain all those sub-dimensions to be sustainable (Kolak, 2015).

Table 1. Sustainability System Dimensions and Sub-Dimensions

| Economic | Social | Environmental |
|------------------------|-----------------------------------|---|
| Economic Productivity | Equity/ Fairness | Climate change prevention |
| Development Resources | Human safety, security and health | Air, noise and water pollution prevention |
| Efficiency | Community development | Non-renewable resources conservation |
| Affordability | Cultural heritage preservation | Open-space conservation |
| Operational efficiency | | Biodiversity preservation |

Source: Kolak, 2015.

The economic dimension of sustainability deals with the economic conditions of businesses, their stakeholders, and their impacts on economic systems at local, national and global levels (GRI, 2013). The Economic Category demonstrates the capital flow between various stakeholders and the main economic impacts of businesses on society (GRI, 2013). There are four main aspects within the economic dimension, as economic performance, market presence, indirect economic impacts and procurement practices, and each of them meets different indicators that provide information about the development and economic impacts of the organization (GRI, 2013).

The social dimension of sustainability primarily focuses on human development; in addition to that, it deals with cultural and social necessities like; permanent establishment of basic requirements such as food and shelter, security, equality, health, freedom, education and employment (Eş, 2008). The social dimension of sustainable development is primarily concerned with reducing poverty, increasing social investments for everyone and building safe and secured communities. (Torjman, 2000). When policy makers develop future scenarios, the social dimension is generally neglected. However, considering the long-standing balance between social and environmental improvements in the market economy, environmental and social dimensions should be developed equally and from the very beginning of the process (Omann and Spangenberg, 2002). There are some other topics related with social sustainability in the current literature that include corporate social responsibility (CSR) and community involvement, as well as the company's position on issues involving women, ethnic minorities, gays, lesbians, bisexuals and transgenderists and disabled individuals (Ugbaja, 2016).

The environmental dimension of sustainability includes the reduction of people's negative impacts on environment and the protection of nature and ecosystems (Eş, 2008). Similarly, Ugbaja (2016), indicates that the environmental dimension of sustainability mainly focuses on preservation of natural resources. Environmental sustainability basically emphasizes that there are renewable and non-renewable resources in our world and humans must act sensitively in the use of all resources (Eş, 2008). To evaluate the environmental sustainability performance system is highly complex (Olafsson *et al.*, 2014) but it is unquestionably a significant concept in policy making

area (Dias, 2017).

2. SUSTAINABILITY IN MULTIMODAL TRANSPORTATION

Intermodal freight transport is a term used to describe the movement of goods in the same loading unit or vehicle, following each other without any action during transfers between multiple modes of transport as road, rail or water (European Conference of Ministers of Transport, 1993). The White Paper of the European Commission, called European Transport Policy for 2010 (European Commission, 2001), recommends the given necessary emphasis to promote intermodal transport, because it reduces the traffic congestion on the roads (Macharis *et al.*, 2007). In the international economy, all supply chain partners (manufacturers, distributors, consumers and transport users) must actively participate in the supply chain process to optimize flow of materials and products (Furtado and Frayret, 2015). Transport companies and third-party logistics companies should look for ways to provide different services for various products at a minimum cost, while at the same time becoming more sustainable (Furtado and Frayret, 2015).

When pros and cons of transportation modes are analyzed, flexible, door-to door and complementary to other transportation modes, road transportations look suitable for short distances with high value added and small volume loads, rail transportation is suggested for big quantity or high weighted goods for distances between 500km to 1200km, on contrary maritime transportation is suitable for very big quantities and over 1200km. distances (Frayret, 2012).

In the current literature, in 2007, Priemus *et al.* studied on the technological and organizational innovations in intermodal systems. They outlined the current multimodality problems of European freight transport and observed promising developments in terminals and networks in technological and organizational concept. MacHaris *et al.*, (2008) conducted a case study in Belgium and examined improvements in intermodal systems by using electric or hybrid trucks for the PPH operations. Their results demonstrate the high traditional costs of road transport, and their calculations show that their suggested system is feasible both organizationally and financially. How current trends affect the role and development of intermodal road-rail transport especially in Scandinavia has been examined by Bergqvist and Floden in 2010. They focused mainly environmental dimension of sustainability and they concluded using intermodal transport instead of road transportation, which is substantial to reduce CO₂ emissions in Sweden. Behrends (2012) also conducted a case study and analyzed urban sustainability used the external costs of a single-modal road transport (Sweden between Gothenburg and Stockholm) versus potential intermodal alternative as sample and concluded that the integration of the intermodal terminal and the shippers' location in the urban structure is required to achieve desired sustainability performance of intermodal road-rail transport (IRRT). All three dimensions of sustainability have been analyzed by Furtado and Frayret in 2015. With the aim to present the freight network performance indicators to evaluate it, they demonstrated a preliminary model of intermodal resource sharing container transport

network. Simha (2016), aimed to analyze freight transportation in India and conducted a case study which especially focused on economic dimension of sustainability. Qu *et al.* (2016), also carried out a case study that used eleven different locations in the UK and focused financial dimension of sustainability as well and they described an intermodal freight transportation model by taking GHG emission cost into account.

3. METHODOLOGY

In this study, content analysis method has been carried out to examine the studies on sustainability in the multimodal transportation concept. According to Hakam and Solvang (2013) the aim of the content analysis is to summarize existing studies by identifying patterns and issues. In line with the given definition of content analysis, the aim of this specific study is to analyze the studies that examine sustainability in the most sustainable mode of transportation which is multimodal transport. To reach this aim, an online search has been made in seven electronic databases that mainly publish maritime and transportation related studies and for which free access has been provided by Dokuz Eylül University, which are: Google Scholar, Ebscohost, Proquest, Science Direct, Scopus, Taylor & Francis and Web of Knowledge (Web of Science). The search terms "multimodal transport sustainability", "intermodal transport sustainability" and "combined transport sustainability" have been scanned for 30 years period through all databases from the period of 1987 to 2017 October. These three key phrases are shown in Table 2.

Table 2. The Search Key Phrases

| Number | Corresponding Phrases |
|--------|-------------------------------------|
| 1 | Multimodal Transport Sustainability |
| 2 | Intermodal Transport Sustainability |
| 3 | Combined Transport Sustainability |

While conducting the scan, some criteria have been used to limit the search. Articles and conference proceedings have been included as source. There also has been a time limit in the search criteria. The literature between 1987 and 2017 has been screened, because as mentioned before, sustainability concept was born in the Brundtland Report of 1987 (Kuhlman and Farrington, 2010), so, 30 years of literature has been determined as acceptable. All scans included in the title of the studies have been carried out, with "containing all of the words" condition. Each key phrases and the relevant paper count are given in Table 3 for each database.

In sample selection process, first the studies, selected through the literature survey, have been analyzed in detail; then, irrelevant studies have been chosen according to their subject, and these studies scanned through different databases have been separated, at the end, the sample of the study has been identified as nine studies. These nine studies have been examined by means of content analysis.

Table 3. Number of Studies Available in Multimodal Sustainability Related Publications from Different Electronic Databases

| Key Phrases/ Databases | Electronic Databases | | | | | | |
|-------------------------------------|----------------------|------------------|-----------|----------|----------------|--------|------------------|
| | Google Scholar | Web of Knowledge | Ebscohost | Proquest | Science Direct | Scopus | Taylor & Francis |
| Multimodal Transport Sustainability | 1 | 3 | 2 | 4 | 2 | 4 | 1 |
| Intermodal Transport Sustainability | 4 | 3 | 7 | 6 | 3 | 4 | 3 |
| Combined Transport Sustainability | 0 | 0 | 2 | 0 | 0 | 0 | 0 |

Content analysis is one of the qualitative research techniques and is used widely describing a family of analytic approaches ranging from impressionistic, intuitive, interpretive analyses to systematic, strict textual analyses (Rosengren, 1981). Mayring (2000), has defined qualitative content analysis as “an approach of empirical, methodological controlled analysis of texts within their context of communication, following content analytic rules and step-by-step models, without rash quantification”. Walcott (1994) argues that the most significant difference between qualitative and quantitative research methods is the data analysis process. The researcher conducting the qualitative analysis, aims to discover and reveal the information hidden in the data by taking the data collected from the field (Özdemir, 2010). In content analysis, the researcher primarily focuses categories related to the research topic, then counts the words, sentences or pictures that fall into these categories in the data set that has been examined (Silverman, 2001). Qualitative content analysis enables researchers to understand social reality in a scientific way; searching for the underlying meaning of physical messages; it is based on the analysis of topics and themes, as well as the interpretation of data extracted from them (Kaid and Wadsworth, 1989). Although it is a single method, existing content analysis practices can be examined in three different approaches, the main differences between which are coding schemes, the origins of codes, and threats to reliability: traditional, directed, or summative (Hsieh and Shannon, 2005).

- In conventional content analysis, coding categories are derived directly from the data in the text.
- Directed content analysis begins with the findings of a theory or related research to guide a first theory.
- Summative content analysis usually involves counting and comparing keywords or content (Hsieh and Shannon, 2005).

Main differences among these three techniques are given in Table 4.

Table 4. Major Coding Differences Among Three Approaches to Content Analysis

| Type of Content Analysis | Study Starts With | Timing of Defining Codes or Keyword | Source of Codes or Keyword |
|-------------------------------|-------------------|---|---|
| Conventional content analysis | Observation | Codes are defined during data analysis | Codes are derived from data |
| Directed content analysis | Theory | Codes are defined before and during data analysis | Codes are derived from theory or relevant research findings |
| Summative content analysis | Keywords | Keywords are identified before and during data analysis | Keywords are derived from interest of researchers or review of literature |

Source: Hsieh and Shannon, 2005.

Summative content analysis has been used in this specific study. A study that uses a summative approach begins with the definition and digitization of specific words or content in the text in order to understand the contextual use of words or content (Holsti, 1969). The purpose of this analysis is to focus on discovering the underlying meaning of words or content (Babbie, 1992).

4. FINDINGS

4.1. Total Number of Publications per Year

Annual distribution of studies in sustainability and intermodal transportation literature is given in Figure 1. According to this figure, most of the studies were published in 2016. However, when it is compared to the studies in other areas like Sustainability in Supply Chain Management, the number of studies in ‘Sustainable Supply Chain Management’ key phrase, is “1245” in just Google scholar database, the number of multimodal sustainability studies in current literature has been found to be very few.

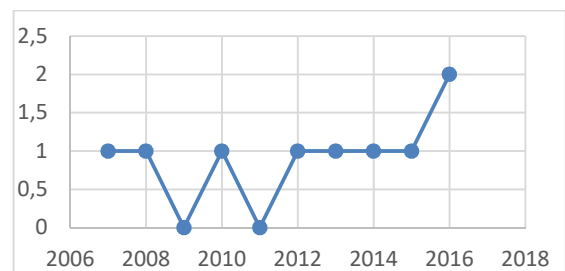


Fig. 1. Total Number of Publications per Year

4.2. Publication Types of the Studies

As for the types of academic publications, it has been concluded that four of them are conference proceedings and five are articles. However, one of the examined articles has been published as an expanded summary, not full text.

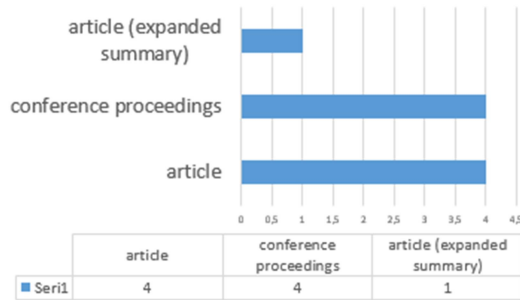


Fig. 2. Publication Types of the Studies

4.3. Journals That Have Published Intermodal Sustainability Studies

According to the content analysis results, only four common journals can be found, which are; Transportation Planning and Technology, Environmental Modelling & Software, Netw Spat Econ and Periodica Polytechnica Transportation Engineering.

4.4. Transportation Modes Used in The Studies

When the transport modes used in the studies are examined one by one, the most used mode has been the Roadway. However, the fact that the use of railroads is close to the roadway, it has taken place among the positive results of this study in terms of sustainability. Unfortunately, only seven studies contain information on the mode of transport used, no information is given in the other two studies. The detailed information on the other transport modes is demonstrated in Figure 3.

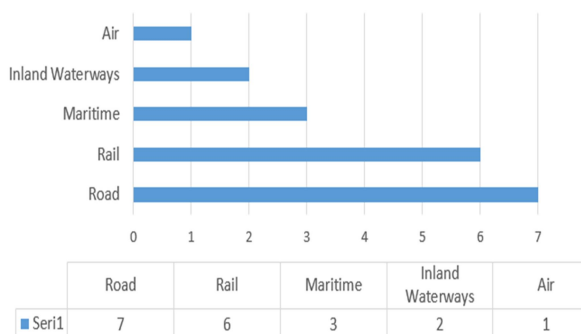


Fig. 3. Transportation Modes Used in the Studies

4.5. Transportation Mode Combinations Used in The Studies

As for the multimodal combinations of transportation modes used in the studies, road and rail

transportation has become the prominent result. The other important combination obtained is road, rail and maritime transport. The detailed information on the other transport mode combinations is shown in Figure 4.

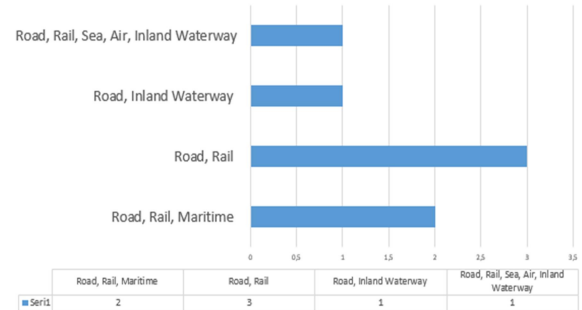


Fig. 4. Transportation Mode Combinations Used in the Studies

4.6. Sustainability Dimensions Included in the Studies

It has been determined that intermodal transport studies concentrate on environmental and economic dimensions of sustainability according to Figure 5. It is observed that the social dimension of sustainability is largely neglected.

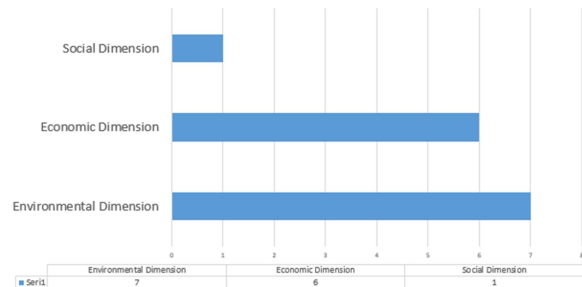


Fig. 5. Sustainability Dimensions Included in the Studies

4.7. Sustainability Dimensions Combinations Used in the Studies

In the case of sustainability combinations, it is observed that in parallel with the previous results in Figure 5, the studies jointly examine the economic and environmental sustainability dimensions. There are also a number of studies that examine just one dimension of sustainability.

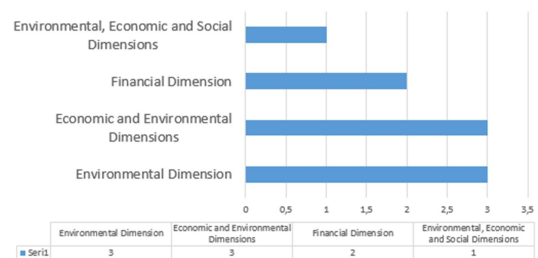


Fig. 6. Sustainability Dimensions Combinations Used in the Studies

4.8. The Main Subjects of the Studies

When the scope of the work is assessed, innovation, urban sustainability and infrastructure issues together with freight transportation draw attention as priority and specific issues as demonstrated in Figure 7.

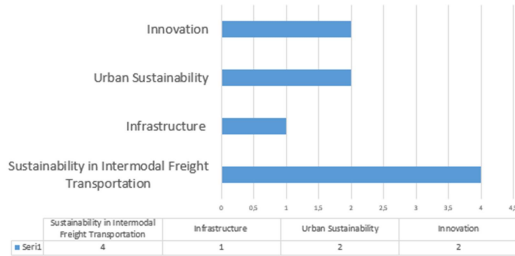


Fig. 7. The Main Subjects of the Studies

4.9. Geographical Areas Used in the Studies

According to the content analysis results, it is observed that most of the studies have used case study method to analyze the sustainability of multimodal transport activities. The main geographical areas that have been used in these studies are listed as follows; The United Kingdom, Argentina, Brazil, Sweden, Gothenburg, Stockholm, Belgium, Canadian cities; Quebec and Ontario, U.S.A, Rhode Island, Massachusetts, New Hampshire, Pennsylvania, Vermont, Maine and New York.

4.10. The Methods Used in the Studies

As mentioned before, it is observed that most of the studies have used case study method to analyze the sustainability of multimodal transport activities. The other methods used in these studies are HIT (Heuristics Intermodal Transport) model, Agent based simulation and conceptual methods.

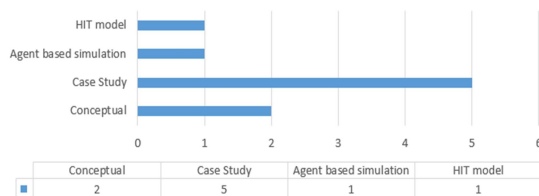


Fig. 8. The Methods Used in the Studies

5. CONCLUSION

The main aim of this study is to analyze the studies that examine sustainability in multimodal transportation, which is the most sustainable transport system. To the authors knowledge, there is no study reviewing sustainability approach in multimodal transportation. Therefore, the main motivation of the study is first, to examine the multimodal transportation studies in the concept of sustainability and to reveal the current shape of these studies, second, to identify the deficiencies and third to provide a road map to the researchers who wish to work in this field.

One of the main results of this study in terms of sustainability is the prominent use of railway transportation in the intermodal transport combinations.

However, the geographies where the studies have been conducted such as; The United Kingdom, Sweden and New York are developed countries in terms of having railway infrastructure and transportation system. Therefore, it is thought to be useful to compare and contrast the samples of less developed and developing countries in terms of sustainable multimodal transportation. Although there are many theoretical studies in the literature (World Commission on Environment and Development, 1987, Pagell and Wu, 2009, Lozano and Huisingh, 2011, Özispa and Arabelen, 2018), about the importance of considering 3 basic dimensions of sustainability together in practice the studies mainly get interested in economic or environmental aspects of sustainability. Likewise, we have found that just one study has evaluated sustainability in terms of all three dimensions of it. Especially, the social dimension of sustainability has scarcely been analyzed in the sustainable intermodal transportation literature. Current literature claim that the social dimension of sustainability is the most neglected dimension in many sectors (Geibler *et al.*, 2006; Oman and Spangenberg, 2002). Geibler *et al.*, 2006, state that due to the abstract and qualitative nature of social sustainability, the provision and measurement of social sustainability is seen as an important challenge for practitioners and they point out the necessity of measurement criteria on which consensus is reached. Likewise, for multimodal transport, which emerged as a sustainable transportation model, it is necessary to establish agreed criteria to obtain and measure social dimension of sustainability as well as economic and environmental dimensions of sustainability. Oman and Spangenberg (2002), have discussed the importance of an equal and balanced approach to environmental and social dimensions in order to ensure social sustainability. In line with this view, studies on sustainability in multimodal transport need to include all three dimensions of sustainability as the basis for and support to each other in order to meet the basic requirements of both multimodal transport and sustainability. Additionally, the case study method, the main purpose of which is to reach the “general” with the special case examined in detail (Deveci and Deveci, 2018), has been identified as the main analysis method used in the studies. It is thought that, to determine a prominent method used mainly in intermodal transportation sustainability studies is useful for literature in terms of creating a road map for future studies. Also, the lack of empirical studies in sustainable multimodal transportation literature is noticeable. So, it would be a lot better if the researchers who will work on this subject prefer conducting empirical methods.

The key phrases used in the study were searched within the name of the studies in all databases, and it is thought that it would be beneficial to make literature searches in keywords or in the whole document. The limited time span is the main limitation of the study, so, the future studies can extend the time span and key phrases used in the studies such as “sustainable multimodal transportation, etc”. Furthermore, it is considered that conducting studies to investigate what social, economic and environmental sustainability criteria should be for multimodal transport will contribute to both practitioners and the current literature.

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