Proceedings of the Hamburg International Conference of Logistics (HICL) – 26

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Published in: Logistics 4.0 and Sustainable Supply Chain Management
Carlos Jahn, Wolfgang Kersten and Christian M. Ringle (Eds.)
ISBN 9783746765365, September 2018, epubli

Supporting the Selection of Sustainable Logistics Locations

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Selecting a logistics location is vital for logistics providers, food retailing and other trading companies since the selection poses an essential factor for economic success. Decisions on logistics locations currently mainly take into account economic factors. Environmental aspects play only a subordinate role, which impedes transparent and sustainable decisions. The result is an impeded dialog between the involved stake-holders within the location decision process, which leads to a dismissive position of municipalities and landowners. Besides logistics location may negatively affect eco systems in terms of sealing the surface, wrecking of biodiversity, or CO2 and noise emissions generated by traffic. The increasing importance of sustainability demands for informed decisions when selecting a future logistics location. Sustainability considers environmental aspects, which should be equally integrated in the process of logistics location search. This paper presents an innovative approach for supporting logistics companies when selecting new logistics locations. Basis for the innovative approach are the Analytic Hierarchy Process (AHP) and the Strategic Environmental Assessment tool (SEA). The presented approach extends the AHP method with content and methods out of the SEA tool for considering more environmental aspects in the logistics location selection process. The paper presents the essential steps for developing the innovative approach considering more environmental aspects which leads to more transparent and objective location decisions.

Keywords: logistics location; location selection; environmental criteria; sustainability

First recieved: 28.May.2018 *Revised:* 07.Jun.2018 *Accepted:* 22.Jun.2018

1 Introduction

Selecting a logistics location is one of the most crucial decision problems for logistics managers and vital for companies out of the logistics business (Pajones, 2017; Chen-Tung Chen, 2001). In this paper, a logistics location is defined as a business or industrial site, where logistic activities take place. Various types of logistics locations exist, like distribution centers, dry ports, city logistics centers and others (Wagner, 2010; Nehm, 2013). Searching for new logistics locations is a complex process, in which a number of factors and criteria need to be considered (Ming-Shin Kuo, 2011). Various research methods are applied which are often part of a multi criteria decision method (Anjali Awasthi; S.S. Chauhan; S.K. Goyal, 2011; Jacek Żak; Szymon Węgliński, 2014; Ming-Shin Kuo, 2011). Multi criteria decision methods are effective in combining qualitative criteria from the decision makers (location criteria) with mathematical modeling methods to determine the best location for logistics usage (Jacek Żak; Szymon Węgliński, 2014). Decisions are the result of a comprehensive choice process with the objective to minimize costs (inter alia, logistics costs or transportation costs.) and maximizing profit (Bloech, 1970; Ashayeri, Jalal; Rongen, Joost M.J. 1997). Besides, subjective decisions by logistics managers also have a significant impact on the selection of logistics locations (Ping-Yu Chang, 2015). Decisions on logistics locations currently mainly take into account economic factors. Ecological and social aspects play only a subordinate role, which impedes transparent and sustainable decisions (Pajones, 2017; K.Sahoo, 2016; Verhetsel, 2015; Kou-Huang, 2014; Hilmola, 2013; Ashayeri, 1997). Logistics locations have significant effects on the environment. Positive effects include revenues for municipalities, jobs or positive effects for the regional economy. Negative effects include sealing of the surface, wrecking biodiversity or CO2 and noise emissions generated by traffi (Nehm, 2013). In addition to these effects, many more impacts exist. When developing new logistics locations, the different interests of the logistics company, the municipality and the inhabitants have to be considered (Nehm, 2013), which is a challenging task. The objective of the paper is to present the essential steps for developing an innovative approach that supports logistics managers in the selection of sustainable logistics locations. It will be demonstrated how sustainable aspects (ecological and social ones) can be integrated into the decision process which leads to more transparent and objective location decisions.

2 Research Design

The innovative approach presented in this paper will demonstrate the essential steps for integrating environmental aspects into the process of logistics location selection.

Literature and secondary data in the fields of logistics location selection and environmental assessment suggests the so called Analytic Hierarchy Process (AHP) and the Strategic Environmental Assessment (SEA) as suitable methods for the economic and environmental assessment of logistics locations. Both methods require a high level of expertise in the fields of economy and ecology. However, logistics managers typically have a higher level of expertise in economics then in environmental issues. A deeper analysis will be conducted to extract the essential steps of the AHP and SEA methods and to acquire knowledge how to apply these methods for supporting the selection process of logistics locations under aspects of sustainability.

The RQ's are defined as follows:

RQ1: How to integrate environmental aspects into the selection process of logistics locations?

RQ2: What are the essential steps of the SEA that should be integrated into the AHP to develop an innovative approach for the selection of sustainable logistics locations?

The remainder of the paper is structured as follows: Chapter 3 outlines the fundamentals of the AHP method and the SEA tool. Chapter 4 describes the essential steps of the innovative new approach that has been developed based on AHP and SEA. Chapter 5 finally concludes the paper.

Table 1: Saaty-scale Source: Stojanov, 2013

Scale value	Definition	Interpretation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgement slightly favor one activity over another
5	Essential or strong importance	Experience and judgement strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance demonstrate in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affi - mation
2,4,6,8	Intermediate values between the two adjacent judgements	When comprise is needed

3 Fundamentals

3.1 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process is a method for multi criteria decision making and was developed from Saaty at the beginnings of the 1980’s. The AHP method enables a pairwise comparison of defined criteria and their alternatives based on the so called ”Saaty-scale” (Saaty, 1980). This ordinal scale is characterized

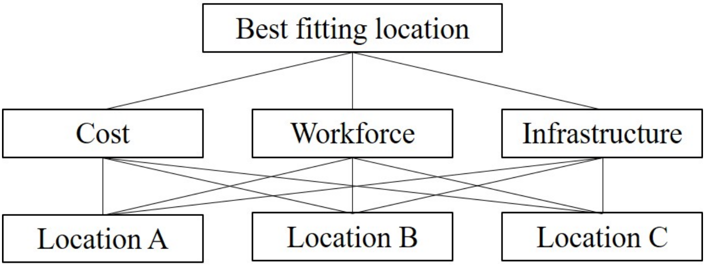

Figure 1: Basic structure of an exemplary hierarchy, own illustration by the author

by nine stages, whereby Saaty recommends the ranks as follows (Table 1), other ranks in between are possible).

The AHP method is based on a hierarchy, where the problem decision is decomposed in top down criteria (Riedl, 2006; Brunelli, 2015; Ping-Yu Chang, 2015). On the lowest level of the hierarchy, the alternatives (Location A, Location B, Location C) are listed. Figure 1 indicates a possible structure of a hierarchy:

The pairwise comparison of the three given criteria has to be conducted as follows:

1) Importance of cost compared to workforce for the selection of the best fitting location

2) Importance of cost compared to infrastructure for the selection of the best fitting location

3) Importance of workforce compared to infrastructure for the selection of the best fitting location

Normally the comparison is done with the help of a matrix, in the given case it would be a 3x3 Matrix. The weightings of each criterion (also called local priorities) are calculated by normalizing the matrix and the sum of the columns and rows. The detailed calculation method is not discussed here, but can be read in the corresponding literature (Riedl, 2006; Brunelli, 2015). The last step is to calculate the global priorities by comparing the alternatives regarding to the respective criteria.

AHP is a powerful method when the decision problem and the hierarchy are complex and many criteria and alternatives are given. Location selection is one of a broad field of application where AHP is in use (Brunelli, 2015). A typical characteristic of this method is that there is less room of manipulation of the results because of the calculation of the weightings based on the pairwise comparison of the criteria. This is a strength of the method compared with similar methods for decision making such as the benefit analysis (Riedl, 2006).

3.2 Strategic Environmental Assessment (SEA)

The Strategic Environmental Assessment (SEA) is a tool to capture and evaluate the possible positive or negative impacts on the environment. Since 2001 the SEA has a legal basis in the European Union and in 2004 the SEA was integrated into Austrian law. In Austria, the SEA tool is used to assess the possible environmental impacts of spatial development plans or land use plans. In this context this tool supports the sustainable development of the country in a strategic way (Austrian Federal Ministry of Sustainability and Tourism, 2018).

Referencing to the SEA guidelines in Austria, SEA is a process which consists on several steps:

1) Screening:
   The screening step is an initial step to check if the complete SEA is necessary or not. A checklist enables a structured revision of the respective plan or project. The result of the screening step is a verbal argumentative overall statement of the relevance of the potential environmental impacts caused by the respective plan or project. If significant effects are detected, then the so called scoping is the next step within the SEA process.

2) Scoping:
   Scoping is essential because it defines the framework of the subsequent investigations. Similar to the screening step a checklist exists, which supports the scoping process for determining the content of the future Environmental Report. Table 2 exhibits the several steps of the Scoping process:

Table 2: Essential steps of the Scoping process, Source: Austrian Federal Ministry of Sustainability and Tourism, 2018

Scoping steps	What	Why
Alternatives	Identification of alternatives	To find the best alternative in terms of environmental impacts, taking into account the objectives of the project or plan.
Environmental impacts	Defining the types of environmental impacts	To define the types of environmental impacts caused by the project or plan and for focusing the content of the environmental report.
Investigation area	Defining the area of investigation	To identify the area which is possibly affected by the environmental impacts of the plan or project.
Target criteria	Defining the target criteria of the SEA	The criteria are based on the relevant environmental targets of the respective investigation area. Defining a target hierarchy is useful to get a structure into the SEA report and for assessing the respective criteria
Period of time	Determine the time period of investigation	The plan or project affects the investigation area over a certain period of time. The time period usually depending to the project and starts with the implementation of the project.
Level of detail	Defining the level of detail of investigation	This step determines the level and depth of further investigation. The depth depends on the respective criteria.

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Table 2 – continued from previous page

Scoping steps	What	Why
Methods	Determine the methods for the SEA	The SEA enables the application of diverse methods for measuring, calculating and assessing the potential environmental impacts caused by the project or plan. This step defines the best fitting method regarding to the examined project or plan.
Environmental protection measures	Listing possible measures for environmental protection	This step enables a listing of possible environmental protection measures, if the estimation is possible or useful.
Data and Information	Outline the needed data	To outline the needed data for decision making, assessing the environmental impacts and controlling.
Stakeholders	Define the involved stakeholders	For defining the relevant stakeholders and experts who will be involved in the subsequent SEA process

3) Environmental Report:
The Environmental Report is the main document output of the SEA process and is based on the results of the scoping process which defines the content framework of the environmental report. The report presents all the assessments, measurements, calculations and analysis carried out in a transparent way.

4) Decision making and public announcement:
   The decisions are made with respect to the results of the environmental report. This step also requires a public announcement of the decision-making.

5) Monitoring:
   This step enables a controlled monitoring of the environmental impacts of the project or plan in case of implementation. It also allows a proactive intervention in case of undesired developments.

The SEA process includes five steps and the implementation is a huge effort, which takes a lot of time and resources. The determination of relevance of the environmental impacts require expert knowledge in the fields of traffic environment and spatial planning. The SEA tool examines environmental factors like human health, water, air, biology diversity, et. al. as well as the interactions between these factors. Various methods are in use to assess the potential environmental impacts of spatial development plans or land use plans (Austrian Federal Ministry of Sustainability and Tourism, 2018).

In the following, an innovative approach for supporting the selection of sustainable logistics locations with respect to economic and ecological issues will be presented.

4 Supporting the selection of sustainable logistics locations

The preceding chapter introduced the SEA tool as a resource intensive process. Because of that, the application of the complete SEA process in terms of location selection is not very satisfactory. For supporting the selection of logistics locations, the AHP method is already in practice. The approach presented in the following section is based on the AHP method and includes suitable and relevant content from the SEA tool.

Table 2 lists the essential steps for supporting the selection of sustainable logistics locations.

Table 2: Essential steps for supporting the selection of sustainable logistics locations

Steps	Experts involved	Steps done in a
Requirements towards the location	High-ranking managers, logistics managers	Meeting
Location search	Real estate developer, location agencies	Meeting
Specification of the logistics building	Engineers, logistics managers	Desktop, meeting
Economic target hierarchy	High-ranking managers, logistics managers, AHP expert	Workshop
Environmental target hierarchy	Spatial planers, environmental engineers, AHP expert	Workshop
Pairwise comparison	Spatial planers, traffi planers, environmental engineers, High-ranking managers, logistics managers, political stakeholders, AHP expert	AHP Workshop
Decision making	High-ranking managers, logistics managers, AHP expert	AHP Workshop

1) Requirements to the location:
   In this initial step, high-ranking managers and/or logistics managers come together to define the requirements towards the future location (location criteria). This implies that there is a need for the company to develop a new logistics location. There may be several reasons for this need such as expansion into new markets, optimizations of logistics costs, etc. The review of existing literature suggests traffi connection, land price, labor force potential and security measures as common criteria. Normally the managers also require the position of the location in a macro- (country) or mesoscopic (metropole region) way.

2) Location search:
   The defined location criteria are the basis for the location search, where real estate developers or business/location agencies search for appro-

priate locations. The searching process is usually supported by location-databases. The AHP method requires pairwise comparing for more than one location.

3) Specification of the logistics building:
The development of the environmental target hierarchy requires detailed information and specification of the future logistics building such as size of the sealed service, handled trucks per day, number of employees, size of the building(s), operation time, building technology, et al. The detailed plans and specifications are made by engineers and logistics managers. The specifications are basic input for the definition of the types of environmental impacts and the environmental criteria for the target hierarchy.

4) Economic target hierarchy:
Based on the knowledge gained in step 1 and 3, high-ranking managers, logistics managers and an expert in the AHP method start working together to develop the economic target hierarchy. In this step, the defined location criteria, as an output of step 1, are classified in a useful way. This step also allows the addition of further criteria or the deletion of existing ones.

5) Environmental target hierarchy:
Supported by an AHP expert, spatial planers and environmental engineers come together to develop the environmental target hierarchy. Based on the information as output of the steps 2 and 3 the environmental criteria are defined. The specifications and information of the project (future logistics building) support them for objective estimation of the environmental impacts caused by the future logistics building. In addition, the methods and steps in the SEA tool (Table 2) support the spatial planers and environmental engineers for more objective estimations.

6) Pairwise comparison:
One of the most innovative steps in the presented approach is to bring together the various experts outlined in Table 2, for the pairwise comparison is. Comparing the economic criteria as well as the environmental criteria leads to objective results. The method also allows a separate evaluation of the comparison of the economic- and environmental criteria, which leads to better transparency.

7) Decision making:
Based on the objective results as an output of the pairwise comparison, the managers can make their decision. Because the AHP method enables the separate comparison of the locations in an economic and environmental way, the decisions can be made in a more sustainable manner.

5 Conclusions and further need for research

The paper presents an innovative approach for supporting the selection of sustainable logistics locations, considering economic and environmental criteria. The application of the Analytic Hierarchy Process - method (AHP) enables the involvement of various experts and other stakeholders in the decision process. Expertise and method knowledge in the field of Strategic Environmental Assessment (SEA) qualifies spatial planners and environmental engineers to estimate the environmental impacts caused by the future logistics location and to develop a meaningful target hierarchy for the AHP process. Bringing together the experts and stakeholders (spatial planers, traffi planers, environmental engineers, high-ranking managers, logistics managers, political stakeholders) in an AHP-workshop for the pairwise comparison of the various criteria and location alternatives leads to more objective results. The final location decision is made by the high ranking logistics managers and based on objective and transparent results from the AHP process.

The implementation of the presented approach is still a resource intensive endeavor and of limited practical use. The increased use in the location selection practice is an open question.

Further research is planned to investigate the knowledge, methods and assessments of environmental experts (spatial planners, environmental engineers).

Objective of these investigations is to generate expertise for qualifying the high-ranking logistics managers to implement the needed developments and assessments (target hierarchy, environmental criteria, pairwise comparison) on their own. This enables an AHP process which takes less resources (less money, shorter time, less experts and stakeholders) in implementation.

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