DOI: 10.2507/33rd.daaam.proceedings.xxx

SITE SELECTION FOR INDUSTRIAL WOOD PROCESSING

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This Publication has to be referred as: Kostic, A[leksandra]; Horman, I[zet]; Kustura, M[elisa] & Timotic, V[alentina] (2022). Site Selection for Industrial Wood Processing, Proceedings of the 33rd DAAAM International Symposium, pp.xxxx-xxxx, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-902734-xx-x, ISSN 1726-9679, Vienna, Austria
DOI: 10.2507/33rd.daaam.proceedings.xxx

Abstract

The wood resource in Bosnia and Herzegovina, due to its nature and structure, and significant natural regeneration, represents a key resource for the development of the wood processing industry. Different types of wood are represented, of which the most important from the industrial aspect are softwood and hardwood types of technical wood. Populations of these species are spread depending on geographical and climatic conditions.
For the proper selection of the location of the factory for industrial wood processing, it is important to take into account several parameters that confirm or do not confirm a certain location in advance. Choosing a location for any investment, including investment in facilities and equipment for wood processing, is a complex process that includes, in addition to technical and physical, economic, social, ecological and other conditions. The paper will use the fuzzy logic methodology and MATLAB as a tool for evaluating location selection. It is necessary to create a model that provides the most desirable location for investment. The parameters that limit the optimal choice of location are the length of raw material transportation, human resources, road infrastructure and energy infrastructure.

Keywords: Fuzzy logic; Factory for industrial wood processing; Benefits and costs; Site selection; Mamdani fuzzy inference systems.

1. Introduction

Wood is a natural material and belongs to renewable resources, and is therefore interesting from the aspect of good physical and mechanical properties and natural decomposition. These properties give it an advantage over other synthetic materials, especially when it comes to environmental protection. Bosnia and Herzegovina is one of the richest European countries with this resource. Traditionally, wood was processed and furniture was produced in the area of the Western Balkans. This is one of the reasons why this paper considers the possibility of investing in this sector. However, it is not enough to have a raw material resource in order to have a successful production of the final product. It is necessary to take into account some other key parameters for the selection of locations for future production. In the first place is the availability of professional workforce. Then, no less important is the road and electric power infrastructure.

Certain regions in Bosnia and Herzegovina were traditionally oriented towards various production, such as mining, agriculture, metal industry, textile industry, food industry, etc. Previously, the start of production was based on assessments of the narrow or wider local community. These assessments were generally confirmed to be correct, although in some cases some subjective influence could be objected to. Wood processing, either primary or final, in the earlier period was mainly located where the highest concentration of raw materials was. The prevailing opinion was that the most important condition for successful business is the proximity of raw resources. Other influential factors were not neglected either, but there was no objective assessment of the justification of the choice of location. In order to achieve a formalization of the subjective assessment that would tend towards an objective assessment, it was necessary to choose a certain mathematical apparatus that analyzes weight influences.

Problems of planning, management and optimization in the production process from the aspect of available human resources are one of the most important factors in the production process. In the paper [6], the role of reducing the executor in production while maintaining the achieved level of production was considered. This is especially evident in emergency situations such as pandemics. The paper [7] presents a new approach of simulated modeling for the assessment of ecological and economic aspects for sustainable business. The problem is defined and then a model is presented that includes the economic and ecological aspects of the production system. The authors in [3] present criteria for choosing a location based on a literature review for a case study conducted on a Swedish company that is present on the global market. Article [8] is focused on the selection of criteria for location selection, based on 111 companies. Priority criteria for selecting a location for a specific production were taken into account. A quantitative model for location selection for some high-tech manufacturing companies can be found in [5]. In the past, site selection was usually qualitative in nature and highly subjective. It is an attempt to introduce a more objective quantitative approach. The most important location selection parameters for high-tech manufacturing companies have been identified, ranked and weighted based on research.

The paper is organized as follows: In Section 2, the basics of fuzzy logic are given. Fuzzy logic methodology for decision making and construction fuzzy rules are given in Section 3. Defuzzification and results are given in Section 4, conclusion and recommendation for further research are in Section 5.

2. Fuzzy Logic

Fuzzy logic is a branch of mathematics that is a generalization of Boolean logic, and has the greatest application in engineering disciplines. For example, the application of fuzzy logic in energy, more precisely for the selection of a location for the use of wind energy as well as renewable energy sources, is given in works [1], [2].

Fuzzy logic is based on Fuzzy-Sets, which were defined as a new term in 1965 [9] with the aim of presenting and modeling uncertainties in linguistics in a mathematically formalized way. Fuzzy-Set is a generalization of the classic set, because with classic sets the membership of the set is extremely distinct, that is, the element belongs or does not belong to the set, and with fuzzy-sets, the element's membership in the fuzzy-set can be characterized by a number from the interval [0,1]. This means that the fuzzy-set membership function maps each element of the universal set to the mentioned segment of real numbers. More information about this can be found in [4].

The first step in applied fuzzy logic is fuzzification. By applying the appropriate membership function, the phaser converts the exact value into the degree of membership. The most frequently used forms of membership function are: triangular, trapezoidal and Gaussian curve. Due to the uncomplexity of the calculation and sufficient accuracy, the use of the triangular rule is preferred. Mamdani and Sugeno are the most frequently used phase inference techniques. Mamdani fuzzy inference process will be used in this paper. The Mamdani phase system is a simple method that can apply the "if-then" rule to control the system. Defuzzification is the reverse process of fuzzification, where the combination of all fuzzy outputs results in a precisely determined numerical value of the output quantity.

The concepts of fuzzy model and probabilistic model are often mistaken one for another. The essential difference between these two terms is as follows. Fuzzy membership function represents the similarity of objects in the context of imprecise definition of features, while similarity provides information about the frequency of repetition. So, fuzzy logic formalizes the subjectivity of human thinking, feelings, language, and probability provides objective statistics in natural and technical sciences.

3. Application of Mamdani Fuzzy Inference System

Fuzzy logic is a form of artificial intelligence. We used Fuzzy Inference System-FIS in MATLAB as a complete control system for decision making. We used Mamdani's method because it is the method most similar to human thinking. For decision-making, we had 12 input variables, which we divided into two groups: benefit and cost. We also had two output variables, so that the first six input variables were tied to the first output variable, and the other six to the second output variable. We also had 30 rules for the decision, the first 15 for the first output variable and the second 15 for the second output variable. We used the *trimf* membership function because it covers all cases well and is easy to compute. The linguistic variables used in the fuzzy methodology are: L- Low, N- Normal, H- High. The division of variables into benefits and costs is shown in Table 1. We used two locations to test our model. Location 1 is a rural location and Location 2 is an urban location. Fuzzy sets are given in Table 4.

Benefits	Costs
B1=Raw material availability	C1=Location cost
B2=Proffesional staff	C2=Construction land cost
B3=Road infrastructure	C3=Environmental concerns
B4=Electrical infrastructure	C4=Distance of administrative headquarters
B5=Telecomunication connectivity	C5=Place of residence of the employee
B6=Educational institutions	C6=Nearby of the protected zone and cultural and historical monuments

Table 1. Classification of input variables

	B1	B2	B3	B4	B5	B6	Result
Location1	0.8	0.3	0.4	0.7	0.6	0.2	0.4485
Location2	0.2	0.9	0.8	0.9	1	0.9	0.6272

Table 2. Overall fuzzy weights for the selected sites based on benefits

	C1	C2	C3	C4	C5	C6	Result
Location1	0.2	0.7	0.8	0.7	0.6	0.6	0.5981
Location2	0.9	0.2	0.6	0.2	0.3	0.9	0.6799

Table 3. Overall fuzzy weights for the selected sites based on costs

Parametres	**Symbol**	**Variable type**	**Linguistic variables**			**Range**
			1	**2**	**3**	
Raw material availability	B1	INPUT	L	N	H	0 - 1
Proffesional staff	B2	INPUT	L	N	H	0 - 1
Road infrastructure	B3	INPUT	L	N	H	0 - 1
Electrical infrastructure	B4	INPUT	L	N	H	0 - 1
Telecomunication connectivity	B5	INPUT	L	N	H	0 - 1
Educational institutions	B6	INPUT	L	N	H	0 - 1
Location cost	C1	INPUT	L	N	H	0 - 1
Construction land cost	C2	INPUT	L	N	H	0 - 1
Environmental concerns	C3	INPUT	L	N	H	0 - 1
Distance of administrative headquarters	C4	INPUT	L	N	H	0 - 1
Place of residence of the employee	C5	INPUT	L	N	H	0 - 1
Nearby of the protected zone and cultural and historical monuments	C6	INPUT	L	N	H	0 - 1
	B	**OUTPUT**	**L**	**N**	**H**	**0 - 1**
	C	**OUTPUT**	**L**	**N**	**H**	**0 - 1**

Table 4. Fuzzy sets

4. Results

In this section, we approach the defuzzification process, because we can directly make a decision from it. In Fig. 1. shows the dependence of costs on location costs and environmental protection costs. It was noticed that environmental protection costs affect the total costs much more than the price of the location, as can be seen from Fig. 1.

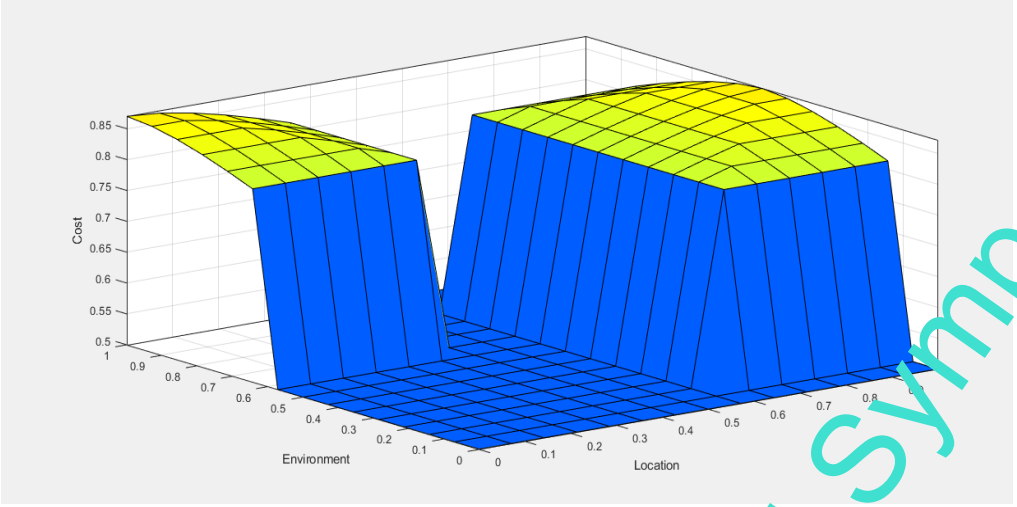

Fig. 1. Fuzzy interface

Our task was to make a decision by applying Fuzzy logic on choosing a location for the construction of a wood factory. We have seen that the defuzzification result for the rural location, Location 1, from the point of view of benefits is $b_1 = 0.4485$, and from the point of view of costs it is $c_1 = 0.5981$, which indicates that when choosing a rural location, the benefits are still far less than the costs. When choosing the urban location, Location 2, the benefit value is $b_2 = 0.6272$, and the cost value is $c_2 = 0.6799$. We can see that the benefit value of the urban location, Location 2 is still less than the cost value, but it is closer to the cost value. In order to make an impartial decision, we will compare the quotients $\frac{b_1}{c_1}$ and $\frac{b_2}{c_2}$.

Since $\frac{b_1}{c_1} = 0.74987 < \frac{b_2}{c_2} = 0.922249$. The decision to build a wood processing factory is in a urban location, which reflects practical experience.

5. Conclusion

In our paper, we used the MATLAB program and its FIS part to select a location for the construction of a wood processing plant. When forming the fuzzy set, we had 12 input parameters, which we divided into 6 parameters representing benefits and 6 parameters representing costs. We used a total of 30 rules for decision making. In order to decide the optimal location for the wood processing factory, we used relevant parameters. The question of determining the site for the wood industry is very important for Bosnia and Herzegovina, because due to the wealth of wood resources, a good part of the gross income is based on the wood industry. To verify our results, we used two sites, one rural and one urban, and we proved that the urban site is much more suitable, because the focus in the modern world is on the human factor and its education. It was also shown that when choosing a location, investment in environmental protection is more important than the price of the land itself or the proximity of wood resources. In further research, it is necessary to collect more specific locations, where it is possible to build a factory for wood processing, and to apply our proposed model to it. It should also be considered whether some other parameters enter the decision-making process and possibly expand the Fuzzy set.

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