A STRATEGIC MODEL FOR LOCATION SELECTION OF WOOD INDUSTRY: AN APPLICATION OF TOPSIS

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Abstract

The location of wood industry has not been selected by proper planning in Iran and for that reason the production rate is not satisfactory. Effective indicators in location of the Industry were identified and a hierarchy was constructed based on five major groups of criteria. The weights of the indicators were then established by Analytical Hierarchy Process. The amounts of the indicators with regard to alternatives were obtained from factories in public and private sectors. These weights were employed in TOPSIS to rank the alternatives. Finally the potential provinces were identified according to the priorities obtained by this technique. The results showed that Kurdistan Province, has the best priorities for establishment of Wood industry plants.

Keywords: Wood industry, TOPSIS, Analytical Hierarchy Process, Location, Priority

Introduction

Location selection for the industries in countries that face scarce resources is a critical problem. In determining the most appropriate location for wood industry, less attention has been made in Iran. This has caused the improper utilization of the resources. Iran is one of the countries, which suffer from scarcity of the resources in this industry, hence it is crucial to have better planning scheme for future production plants. The existing factories often face problems such as large amount of waste in raw material, high transportation costs, stoppage and, at times, complete factory shutdown (Saeed, 1996). Operation within this sector dates back 45 years, but progress has been unsatisfactory. Comparison of volume of wood industry in part of plywood and veneer in the ten years leading to 1999, compared with 25 developed or underdeveloped countries, reveals Iran to be ranked the lowest in the world, with only a 1.2% global share of the plywood industry, and 3.5% in veneer (FAO, 1999). At present, 18 plywood & veneer factories are in operation. The market demand necessitates more factories to be established. Now the question is with respect to production sources, demand nodes and other influencing factors, how many of and where these factories should be set up. All of species that are used in the Iranian plywood and veneer industries are hardwoods. Table 1 shows these species used in plywood and veneer industries, along with their density values (Parsapajouh, 1984):

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Table 1. Species used in the Iranian plywood and veneer industries and their densities

Name of species	Wood density(g/cm^3)
Fagus orientalis	0.67
Acer insigne Boiss	0.53
Acer laetum	0.64
Tilia begonifolia	0.52
Ulmus glabra	0.65-0.68
Alnus subcordata	0.54
Juglans regia	0.6
Qyuercus castaneaefola	0.79
Ulmus carpinifolia	0.74
Carpinus betulus	0.7
Fraxinus excelsior	0.71
Zelcova carpinifolia	0.75-0.8
Populus alba	0.5
Populus nigra	0.45

Studies on site selection for wood production by Michael et al (1998), identified a number of factors affecting the selection decision. They clustered the criteria into cost, market distribution, lower production cost and non-tangible factors. McCauley and Caulfield (1990) specified the effective criteria for selection of an OSB (Oriented strand board) factory and developed a mixed integer programming model to determine the optimal location of the OSB sites. The factors affecting this model were access to raw material, transportation costs, access to suitable manpower, factory capacity, cost of production, profitability, market observations and investment-requirements. Lin et al (1996) presented a computerized model for determining the optimal location and size of OSB plants. They considered the continuous supply of the raw material and economic productivity beside other factors. Azizi et al (2003) used AHP to determine effective criteria for location selection of plywood and veneer units, identifying 25 criteria and sub-criteria.

Modeling the selection problem

The modeling consists of two main stages. In the first stage an AHP(Saaty,1999) model is constructed to evaluate the importance of the criteria and the second stage then employs the TOPSIS (Technique for order- preference by similarity to ideal solution) method to rank the alternatives.

First Stage

In order to analyze the candidate locations and identify the most preferred ones, the initial step is to identify the criteria. A comprehensive list of factors was prepared and a questionnaire was designed to evaluate their contribution in decision process in the case of Iran. This questionnaire was distributed among experts in 4 Iranian factories. The final set of the attributes was concluded via a Delphi method. A hierarchy of these factors was constructed to establish their weights, using Analytic Hierarchy Process (AHP). The pair-wise comparison matrices were completed by 20 experts from industry and academia. The individual judgments were directed towards consistency and the aggregated opinion was derived using TEAM- EC 2000. Figure 1 shows the hierarchy structure of the attributes influencing decision on selection of sites for wood industry.

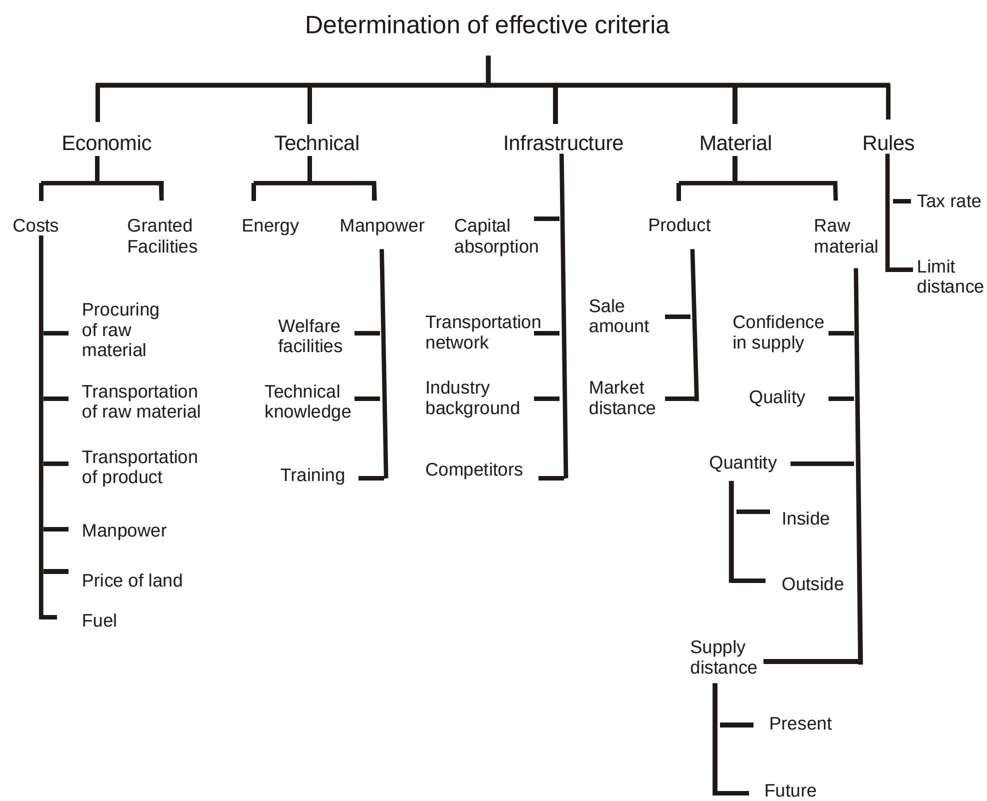

Fig. 1: The hierarchy of criteria and sub-criteria

Below, the attributes used in the model are detailed under the criteria of: economics; material and product; infrastructure (environmental); technical and human; and rules and regulations.

1. Economical criteria

This group of criteria consists of the following sub-criteria:

1.1. Costs:

1.1.1. Cost of transportation of the raw material: Cost of transportation of raw material from supplying resources and offering them (forest, poplar plantation or import origins) to the manufacturing plant.

1.1.2. Cost of procuring raw material: Cost of procuring each cubic meter of forest wood, poplar or orchard wood from their supplying sources to end product.

1.1.3. Cost of transportation of products: Cost of each round of transportation of final products to the sales market.

1.1.4. Manpower costs: Average monthly wages of manpower employed in the manufacturing plants.

1.1.5. Fuel cost: Cost of consumed fuel in plant including gas oil, mazut or gas per cubic meter or per liter.

1.1.6. Price of land: Average price of each square meter of land in the region, for construction of a factory.

1.2. Income:

This criterion covers the facilities and aids, granted by the government to the manufacturing plants located in a specific region in the form of loan and tax exemptions for erecting a factory.

2. Material and product criteria

Material and product criterion contains required raw material on one hand and factory end product. Meanwhile their properties can be effective in location selection of a factory.

2.1. Raw material:

The required raw material for plywood and veneer industry including round-cut forest wood, poplar or orchard wood. In this respect, reliability sub-criteria covers supply, distance from raw material, quality of raw material and quantity of raw material.

2.1.1. Confidence in supply: Rate of confidence for accessibility to raw material in the region or continuation of the material in future.

2.1.2. Distance from raw material: The distance between the region and the place where raw material is supplied including the distance between the region and forests or poplar plantations (existing supply distance). In cases part of the raw material is supplied from foreign resources we must know the distance from country's importing point to the factory (supply distance in future).

2.1.3. Quality of raw material: Quality of the raw material in plywood and veneer industry is of great importance and we must ensure that first and second class would be used.

2.1.4. Quantity of raw material: One part of the material can be supplied from inside the region and the other part is supplied from outside the region. This division is laid to emphasize those regions which have potential to supply raw material.

2.2. Final product:

Final products of the manufacturing plants including veneer and plywood. Regarding final product, amount of sales and distance from sales market are of importance.

2.2.1. Amount of sale: Amount of product that can be sold in target markets and in the region where the factory is located.

2.2.2. Distance from market: Distance of the region from the place or places where the products are consumed or sold.

3. Infrastructure (environmental) criteria

In each region, factors like transportation network, how the competitive industries face the construction of new manufacturing plants, industrial background and the possibility to absorb investment in the region to establish manufacturing plants are considered as infrastructure criterion.

3.1. Transportation network:

Number, distance and type of roads, highways and railroads existing in the region.

3.2. Competitors:

Amount of resistance by competitive industries in the region in the construction of plywood and veneer plants

3.3. Background of Industry:

Background of the region in terms of existence of similar manufacturing plants.

3.4. Absorption of capital:

Region's potential in terms of absorption of capital or local facilities which make the investor interested in building plywood and veneer factories.

4. Technical and human criteria

Technical requirements of the region to establish plywood and veneer factory, which include energy and manpower.

4.1. Energy:

In any region, existence of water, electricity and fuel are important criteria for construction of factory.

4.2. Manpower:

Means supplying required manpower and access to specialized and experienced manpower in the region. Training the manpower, employee welfare facilities and technical knowledge of the manpower are sub-criteria for manpower.

4.2.1. Training: Technical and vocational training center or schools, research centers and similar institutes are needed to train manpower.

4.2.2. Technical knowledge: Information and technical experience in plywood and veneer industry will improve the quality and quantity of products.

4.2.3. Facilities: Health and welfare facilities such as housing, recreational places, telecommunications and education centers, and hospitals will help to attract experienced manpower to the region.

5. Rules and regulations criteria

By this criterion we mean those current state regulations governing tax on industries and distance of factory from cities.

5.1. Tax rate:

Tax on manufacturing plants is imposed based on percentage of factory profit. In some parts of country some plants are exempted from government tax in order to offer incentives for investment and help the industry (Davani, 1999).

5.2. Limit of permissible distance:

To avoid concentration of industries and air pollution problems, government has set a limit for cities where factories cannot be erected. Outside that limit manufacturing plants can be built.

Table 2 shows the weighing value of the 25 attributes influencing decision on selection of sites for wood industry.

Table 2. Description of the criteria and sub criteria

Row	Name of criteria	Form of data	Kind of criteria	Weight of criteria	Description
1	Purchase of raw material	Fuzzy	Cost	0.155	Purchase of raw material (Rials/M3)
2	Transportation cost of raw material	Fuzzy	Cost	0.052	Transportation cost of raw material (Rials)
3	Manpower cost	Fuzzy	Cost	0.035	Manpower cost (Rials/Person)
4	Transportation cost of product	Fuzzy	Cost	0.019	Transportation cost of product (Rials)
5	Price of land	Fuzzy	Cost	0.016	Price of land(Rials/M2)

6	Fuel cost	Deterministic	Cost	0.009	Fuel cost (Rials/Liter or Rial/M3)
7	Granted facilities	Fuzzy	Benefit	0.093	Granted facilities by government
8	Confidence in supply	Fuzzy	Benefit	0.146	Confidence in supply
9	Quality of raw material	Fuzzy	Benefit	0.095	Quality of raw material
10	Quantity of raw material (inside)	Deterministic	Benefit	0.042	Quantity of raw material (inside the region, M3)
11	Quantity of raw material (outside)	Deterministic	Cost	0.007	Quantity of raw material (outside the region, M3)
12	Supply distance (present)	Deterministic	Cost	0.019	Supply distance (present, Kilometer)
13	Supply distance (future)	Deterministic	Cost	0.006	Supply distance (future, Kilometer)
14	Sale amount of product	Deterministic	Benefit	0.05	Sale amount of product(M3)
15	Market distance	Deterministic	Cost	0.012	Distance from market(Kilometer)
16	Capital absorption	Fuzzy	Benefit	0.054	Capital absorption
17	Transportation network	Fuzzy	Benefit	0.041	Transportation network(highway, road, rail)
18	Industry background	Fuzzy	Benefit	0.012	Industry background
19	Competitors	Fuzzy	Cost	0.011	Competitors
20	Energy	Fuzzy	Benefit	0.049	Energy(water, electricity)
21	Welfare Facilities	Fuzzy	Benefit	0.02	Welfare Facilities
22	Technical knowledge	Fuzzy	Benefit	0.013	Technical knowledge
23	Training	Fuzzy	Benefit	0.004	Training
24	Tax rate	Fuzzy	Cost	0.029	Tax rate
25	Limit distance	Deterministic	Cost	0.011	Limit of permissible distance(Kilometer)

Second stage

In the second stage, the data for the attributes were collected from the alternative locations. For this, the questionnaires were presented to the managers of the neighboring factories. Then the Fuzzy Decision Making (FDM) (Memariani, 2000), software was used to rank the location because the data for certain attributes were either qualitative or imprecise. This software is base of on Fuzzy version of TOPSIS. It incorporates besides quantitative information, the imprecise (Fuzzy numbers) and qualitative (linguistic) data. Figure 2 shows the description of the problem in FDM.

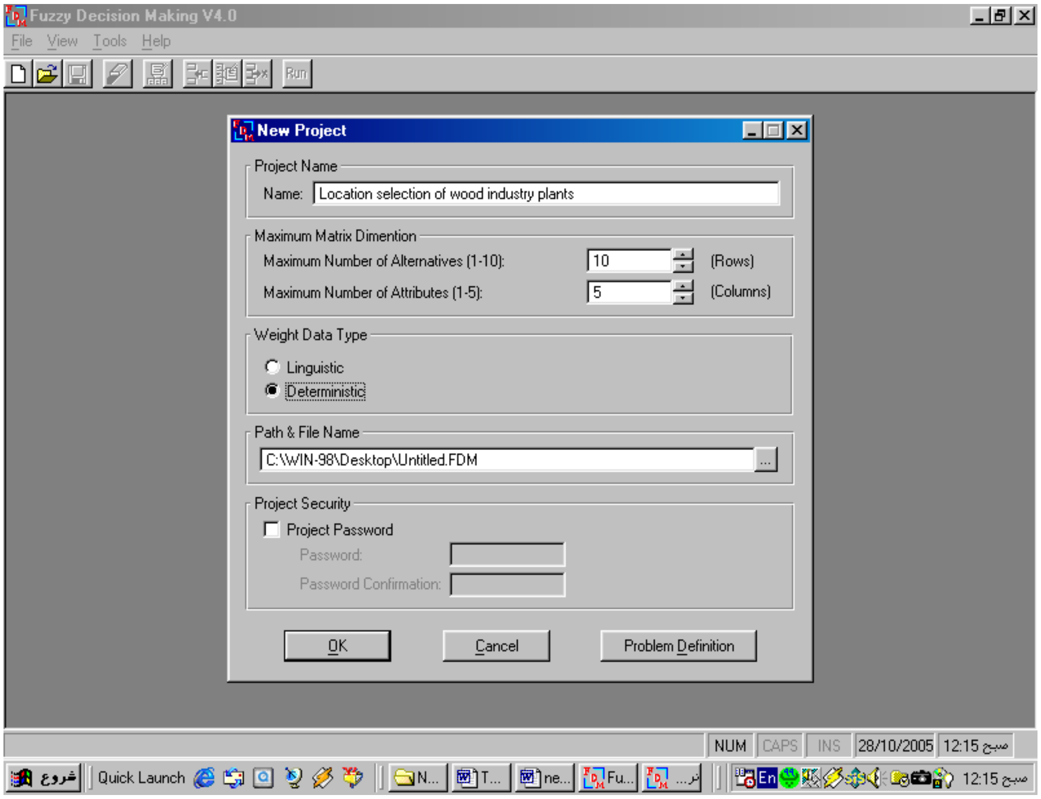

Fig. 2: Description of the problem in FDM

The software is also capable of generating detailed description and analysis of the decision problem in an intelligent report form. The weights are calculated as follows:

The questionnaires of the data for the attributes were distributed to the selected locations and then collected as the source of information. Some of the data were linguistic type while some of them were deterministic. Some kinds of attributes were divided into cost or benefits, depending on being considered as desirable or undesirable by the decision makers (Table 2). For applying FDM software, the linguistic data were converted to fuzzy data (Table 3). A sample of the attributes is shown in Fig.3.

The trapezoid fuzzy data is in the form of m1, m2, a, b, where 'm1' means a lesser approximate value, 'm2' a more approximate one, 'a' the left tolerance 'm1' and 'b' represents the right tolerance of 'm2'. A sample of the data entry and its matrix in FDM software is shown in Fig 4. This results in a matrix of 25*25 in the present research.

In the next step, the fuzzy numbers are converted into real numbers by using defuzzification methods. Then, the matrices are normalized to do away with dimensions of indicators and their coefficients are multiplied by the related vector. We can obtain the radius value of any alternatives in an 'n' dimensional space (where n means number of indicators) by finding ideally positive and negative solutions. The final advantage of each alternative is because of its relative proximity to positive ideal response (Hwang & Yoon, 1981).

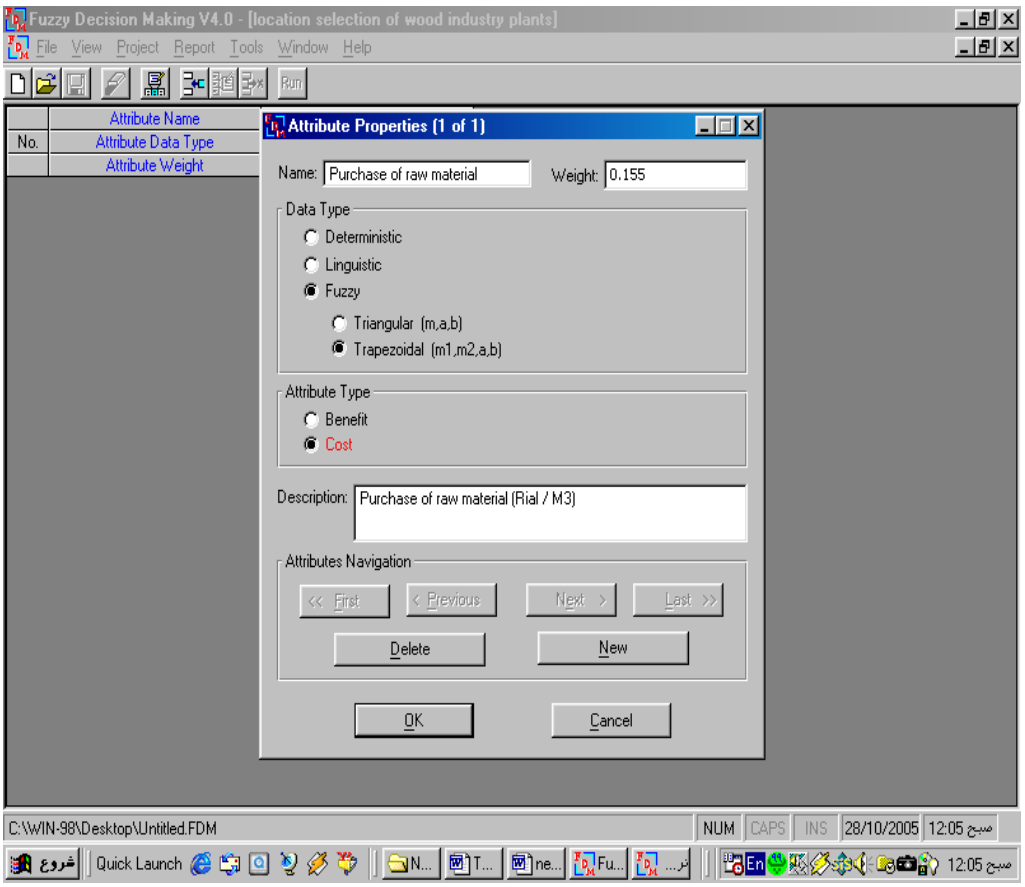

Fig. 3: Description of the criteria in FDM (A sample)

Table 3. The conversion of linguistic data to fuzzy data

Linguistic data	Fuzzy data(m1,m2, a, b)
Very low	0, 0.1,0,0.1
Low	0.2,0.2,0.1,0.1
Fairly low	0.3,0.4,0.1,0.1
Average	0.5,0.5,0.1,0.1
Fairly high	0.6,0.7,0.1,0.1
High	0.8,0.8,0.1,0.1
Very high	0.9,1,0.1,0

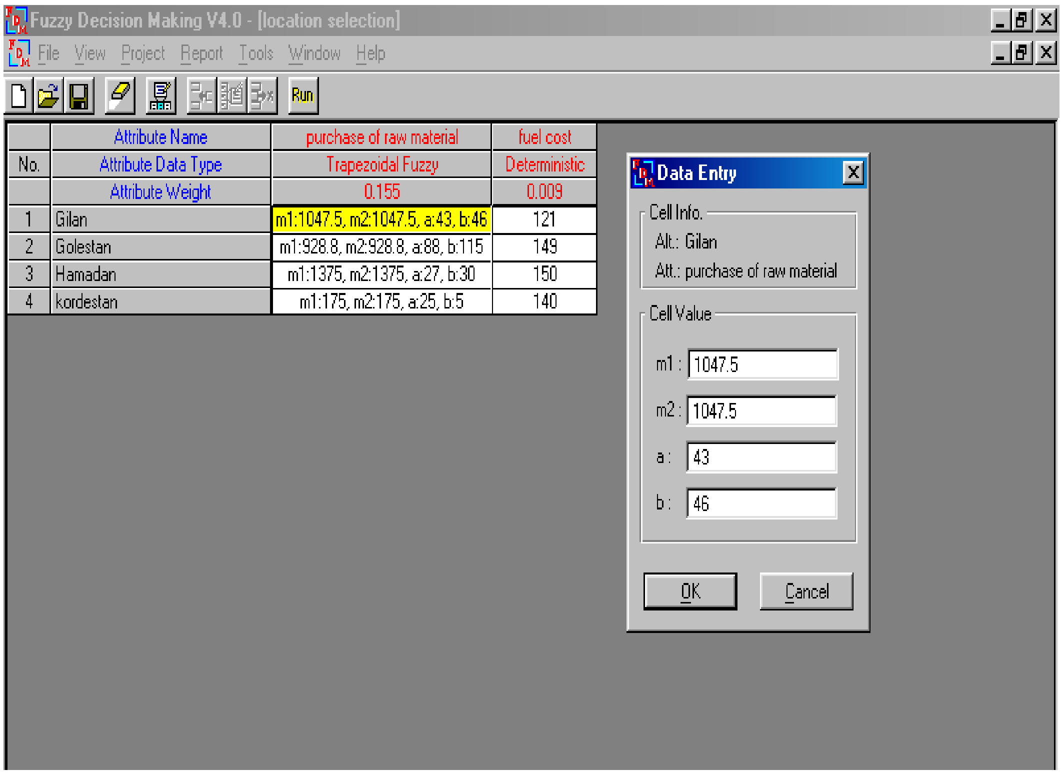

Fig.4: Description of the matrix and data entry in FDM (A sample with 4 alternatives and 2 attributes)

Results and conclusion

The 25 location candidates were ranked using FDM software and the ranking result is presented in appendix 1. At present, 18 factories are in operation and their production capacity is 36595 m3. The analysis shows that if 18 factories were ranked prior to establishment of the existing factories, 4 factories should be closed and instead of them 4 other alternatives should be selected. It shows that existing locations are not optimal. If we increase the number of alternatives to 20 then 3 factories should be displaced. If we increase the number of selected alternatives to 22, then still 2 factories should be displaced. Table 4 shows these results and also the change in total capacity and total capacity promotion due to different scenarios.

Table 4. The analysis of ranking

Capacity's promotion(m^3)	Total capacity(m^3)	Number of factories to be closed	Rank
-	32300	4	18
-	32634	3	20
-	36354	2	22
+1832	38427	0	24
+2532	39127	0	25

To validate a research of this kind, either after the implementation of the result, one should check the impact of the decision in real world or before the implementation, some authorities should confirm this based on their expertise. The former approach was followed. For this, the results were presented to a group of 10 people both from industry and academia. 50 % of this group had already been consulted in the process of the research for attribute establishment and priority setting and the rest were unaware of the process of study. The first subgroup, all accepted the results. Among the second subgroup, 2 persons confirmed the results, 2 persons accepted the results except some of the alternatives to be displaced in ranking and one person totally denied the results. A cross check was also performed with the industrial ranking carried out by the Planning and Management Organization of Iran , (Planning and Management Organization of Iran,1989) in which Kurdistan Province was in a high priority for cellulose industries.

For future investigation it is suggested that a study may be conducted to determine the type of technology with respect to the cost of human resources and also employment generation. Further study is recommended to establish a relation that can determine the size and capacity of each unit with respect to availability of raw material and the market demand.

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Appendix 1:

Ranking of alternative locations

Rank	Province	Score	Number of the locations to collect the data
1.	Kurdistan	85.19	1
2.	West Azarbaijan	65.62	8
3.	Lorestan	63.2	1
4.	Chahar Mahaal and Bakhtiari	60.92	2
5.	Zanjan	60.78	3
6.	Gilan	58.72	5
7.	Kermanshah	58.16	2
8.	Ardabil	57.82	3
9.	East Azarbaijan	54.4	12
10.	Mazandaran	52.96	9
11.	Golestan	52.83	4
12.	Kohkiluyeh and Buyer Ahmad	49.8	1
13.	Markazi	49.37	3
14.	Isfahan	48.74	5
15.	Hamadan	46.55	2
16.	Qom	46.07	5
17.	Khorasan	45.49	4
18.	Fars	44.3	2
19.	Ilam	42.87	1
20.	Semnan	40.18	1
21.	Kerman	39.58	1
22.	Qazvin	36.33	3
23.	Yazd	35.49	1
24.	Tehran	23.88	4
25.	Khuzestan	22.23	1