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EVALUATION OF IRANIAN WOOD AND CELLULOSE INDUSTRIES

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Abstract: *Iranian Wood and Cellulose Industries (IWCI) are distinguished via a minimum quantity of wood consumptions with high wastages rates along with favourite products generation. IWCI exposed to lots of obstacles in the way of maturation and expansion especially in terms of technologies assigned and overdependence on input materials entered into industries cycle. Present cluster study of IWCI empirically targeted an assessment of technologies, input and output materials streams, existing facilities in industries individually. SPSS Software along with Delphi Fuzzy theory and Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methods were assigned to evaluate the data of industries as findings of Iranian evaluator team once before construction of industries. T-test analysis had represented significant differences around (pvalue≤ 0.001, 0.002) among main criteria of IWCI such as the number of employees, power, water and fuel exploitations and the land area occupied by each industry. Using Friedman test the ranks values were obtained about 2.59, 4, 1.53, 1.88 and 5 for the number of employees, power, water, fuel consumed and land area applied in the location of industries. Analytical Hierarchy Process (AHP) via Delphi Fuzzy set, Fuzzy TOPSIS and TOPSIS resulted to a hierarchical classification among IWCI.*

Key words: *Evaluation; Iranian wood and cellulose industries; TOPSIS.*

1. Introduction

The use of wood in Iranian ancient refers to before the Aryan migration from about 4200 BC. Wood industry has got an extensive range of applications both as commercial and industrial demands in Iran. Obviously, population growth aligned with escalated consumption patterns, industries and urbanity developments, have culminated demands for wood and its products in Iran. Iranian statistics centre has recently reported to around 226 industrial production sites of furniture with approximately 10,000 employees are currently running along with around 46,700 wood industries offices operating 117,000 at the native workshops. The value-added of wood products has been recently reported approximately 30% apart of value-added percentage

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associated with the furniture industry (totally 70%). 5% of the industry's value-added devoted to both industrial printing (4.6%) plus Iranian Cellulose industries. The per capita consumption rates for various paper and paperboard types has been estimated at around 23 kg in 2016 with a rise from 12-13 kg to 23 kg in comparison to 10 years ago. This amount has been forecasted in high amounts, (with a factor of 2) for other nations over the world. On the other hand, Iranian people stake in various paper and paperboard consumptions are negligible. The prominent stake for both of paper and paperboard productions has devoted to linerboard and fluting applications which comprise approximately 50%; employed in sheets and cardboard boxes generations and their equipment. In the SWOT analysis, many strength points determined for IWI such as longtime production background, various academic and vocational centres and also well trained and well-experienced labour forces in various fields, creating a high value-added percentage, high-quality products manufacturing in comparison to imported products. However, many drawbacks have also reported for aforementioned industries such as dependency to rare domestic resources, old fashionable equipment and machinery, exhausted devices, bereavement in special tariff proclamations, high transportation outlays and deficiency of investment for requested infrastructure. According to aforementioned advantages and drawbacks, stakeholders need to consider to some opportunities to pave the way for more advancement and development in the field of wood industries.

Globally, the lumber & wood products are divided to many sections such as (1) Hardwood dimension and flouring mills (2) Millwork (3) Hardwood veneer and plywood (4) Softwood veneer and plywood (5) Structural wood members (6) Nailed and lock-corner wood boxes and shook (7) Wood pallets and skids (8) Wood containers (9) Wood preserving (10) Wood products, (11) Pulp mills (12) Wood kitchen cabinets (13) Prefabricated wood buildings and components (14) Wood household furniture, except upholstered wood television, radio, and phonograph cabinets (15) Wood office furniture (16) Sawmills and planing mills (17) Special product sawmills (18) Particleboard. In Iran, there are many cases of wood and cellulose products industries such as Cooler bangs (1), Carton (2), Industrial drying wood (3), Hydrophilic cotton (4), Sheet rolls and packing (5), Wax paper (6), Booklet (7), Hasp (8), Decal (9), Multilayer paper bags (10), Row board (11), Wooden and paper disposable products (12), Wooden pencil (13), Carbon paper (14), Parquet (15) Wooden sandpaper (16) (Iranian industries organization, 2018).

In accordance with the approval of government agencies, any industrial project prior to construction requires the financial, technical and environmental assessments etc. According to the current assessment of the Iranian Industries Organization, in a cluster study, about 16 types of wood and cellulose industries have been identified. In the present study, raw data are generally presented in the framework of a PhD thesis with existing methods for evaluating the project and obtaining the best possible decision-making processes.

Using Multi-Criteria Decision Making (MCDM) models to weight and rank the various data will result to generate different values for the same data employed. The MADM practices need to each alternative to be evaluated against amounts of rating devoted to the attributes, factors and criteria containing various units of measurement for each of them. To compare obtained results associated with each factor or criterion a normalization process is accomplished and the results will offer its own value in integrating the diverse measurement units. The main reason for the normalization process gets back to shift the various assessed units into a non-dimensional scale. By the way, normalized values follow non-declining amounts in the range of 0 and 1 (Gul et al., 2018). Applying AHP, for decision-making processes gets back to Saaty (1980), in an effective and robust practice to model the sophisticated decision difficulties. This practice encompasses complex factors and criteria by deconstructing and dividing them into various easy sub-items so that assign the hierarchical classification, in which the main objective placed in the top level, sub-objectives or accessory options at below clusters and in the following the possible options are embedded in the last level. By the definition, the AHP method is an economic multi-criteria practice of analysis pertaining to a weighting style, in which lots of proper contributions are released based on their relative importance. TOPSIS method, first time acknowledged by Hwang and Yoon (1981), who employed the basic implication of positive and negative ideal solutions in which the determined factors and criteria should have the shortest distance from the positive ideal solution, and the farthest distance from the negative ideal solution (Yazdani-Chamzini et al., 2014). In the uncertainty situation, TOPSIS method is assigned to realize and identify the difficulties so it offers a certain solution. An ideal solution includes the best response or alternative amounts for each factor and criterion. In some cases using TOPSIS for identifying ambiguous data brings some other difficulties so in this cases in order to overcome this restriction, the fuzzy set theory can be employed with the traditional TOPSIS approach to permitting decision-makers to integrate vague data, non-obtainable information, and relatively ignorant facts into the decision model to solve various difficulties and challenges successfully (Zare et al., 2016). Therefore, according to the objective of paper as evaluation of IWCI, the present study included the flow diagrams of running processes, input and output materials flows entered and outsourced from industries along with equipment and facilities used at each industry. The Fuzzy Delphi logic and Fuzzy TOPSIS and TOPSIS (based on real data) were assigned to assess the factors and criteria and in the following industries hierarchically classified, weighted and ranked, values were calculated based on available information.

2. Literature review

Mardani et al. (2016) assessed around 10 biggest Iranian hotels via fuzzy set. Yazdani-Chamzini et al. (2013) assigned Fuzzy TOPSIS to assess the difficulties of investment strategy selection. Zagorskas et al. (2014) investigated the growth in building refurbishment of new-build projects and historical buildings preservation involvements via TOPSIS technique. Nikas et al. (2018) evaluated the gap between climate policy to find a methodological framework to remove existing complex problems using both Delphi and TOPSIS methods. Cavallaro et al. (2016) employed a prioritization method for factors and criteria of combined heat and power systems via both Fuzzy Shannon entropy and Fuzzy TOPSIS methods. Moghimi and Anvari (2014) utilized Fuzzy MCDM approach among 8 Iranian cement companies pertaining to financial statements.

3. Methodology

3.1. Friedman test

Present cluster research of IWCI was empirically performed to evaluate and assess the data of industries. In order to carry out the research, secondary data were gathered from the Iranian Industrial organization database along with findings of evaluator team of environment protection agency. Then secondary data were processed by the

MCDM methods supported by SPSS software (IBM SPSS Statistic 20) in order to classify the aforementioned industries hierarchically. Data were analyzed using the Friedman test and statistic tests for distinguishing initial ranking and realizing significant relations among them. Friedman test assumes the data as a matrix with certain columns and rows ([Xij] n×k in a matrix with n rows, k columns). Actually, to the object, i is added the rank ri, j by judge number j, where it appears in whole n objects and m amount. Therefore, taking into account equations 1 to 6, the initial processing is done on the data by software. Then, equation 5 is used for a general ranking of any factor having the specified values in the columns. The overall ranking can be checked with the analogous test to Friedman test called Kendall. Kendall's W is a non-parametric statistic test and can be assigned for normalization of the results of Friedman test, as well as investigating agreement among values. W in equation 9 is linearly joined to the mean value of the Spearman's rank correlation coefficients between all pairs of the available rankings. The symbol of S (in equation 8), is the sum of squared deviations appeared below. Therefore, equations 6 to 9 are applied to process total rank given to object i which obtained from the Friedman test. The results obtained at this step can be used to investigate Friedman test results (Wittkowski, 1998).

$$\hat{\mathrm{r}}.\mathrm{j} = \frac{1}{\mathrm{n}} \sum_{i=1}^{n} rij \quad (1)$$

$$\hat{\mathrm{r}} = \frac{1}{\mathrm{nk}} \sum_{i=1}^{n} \sum_{j=1}^{k} rij \quad (2)$$

$$\mathrm{SSt} = \mathrm{n} \sum_{j=1} (\hat{\mathrm{r}}.j - \hat{\mathrm{r}})^2 \quad (3)$$

$$\mathrm{SSe} = \frac{1}{\mathrm{n(k-1)}} \sum_{i=1}^{n} \sum_{j=1}^{k} (rij - \hat{\mathrm{r}})^2 \quad (4)$$

$$\mathrm{Q} = \frac{\mathrm{SSt}}{\mathrm{SSe}} \quad (5)$$

$$\mathrm{Ri} = \mathrm{n} \sum_{j=1}^{m} (ri, j, ..) \quad (6)$$

$$\mathrm{Rave} = 1/\mathrm{n} \sum_{i=1}^{n} \mathrm{Ri} \quad (7)$$

$$\mathrm{S} = \sum_{i=1}^{n} (\mathrm{Ri} - \mathrm{Rave})^2 \quad (8)$$

$$\mathrm{W} = \frac{12\ \mathrm{S}}{\mathrm{m}^2 (n^3 - n)} \quad (9)$$

3.2 Fuzzy set theory

In this section, the equations of 10 to 17 are introduced, which are explained below. The Delphi Fuzzy system used in this research is displayed as triangular Fuzzy numbers according to Figure 1. The weighing system complies from a pattern as, $\sum_{j}^{n} \mathrm{Wj}$, (j=0-1). Initially, the factors and criteria used are represented by linguistic words, real and Fuzzy numbers according to Table 1.

Table 1. Delphi Fuzzy set

Linguistic words	Symbol	Fuzzy No	Crisp No
Very low	VL	(0.09,0, 0.1)	0.1362
Low	L	(0.2, 0.1, 0.1)	0.2272
Slightly low	SL	(0.3, 0.1, 0.2)	0.3695
Medium	M	(0.5, 0.1, 0.1)	0.5
Slightly high	SH	(0.6, 0.1, 0.2)	0.6304
High	H	(0.8, 0.1, 0.1)	0.7727
Very high	VH	(0.85, 0.1, 0)	0.8636

Current Fuzzy values (M, a, b) are able to transform as m2+b to m1-a. By the equations of 10 to 12 (N= m, a, b) Fuzzy numbers can be displayed in Figure 1. By the way, Fuzzy numbers are represented by some symbols and also real numbers which can be converted to Fuzzy numbers. In this research, equation 13 was used to prioritize factors. Using a data classification system, the actual numbers obtained by the evaluator team were classified in certain intervals. As a result, Table 5 was formulated as a criterion/factor versus symbol in the Likert scale. The special vector (A vector is defined as a rank value obtained from criteria and factors in columns) was acquired by the results of the Friedman test. The Weighted Sum Vector (WSV) is the summation of the weight of each criterion (W) multiply in assigned Fuzzy number (D) according to equation 14.

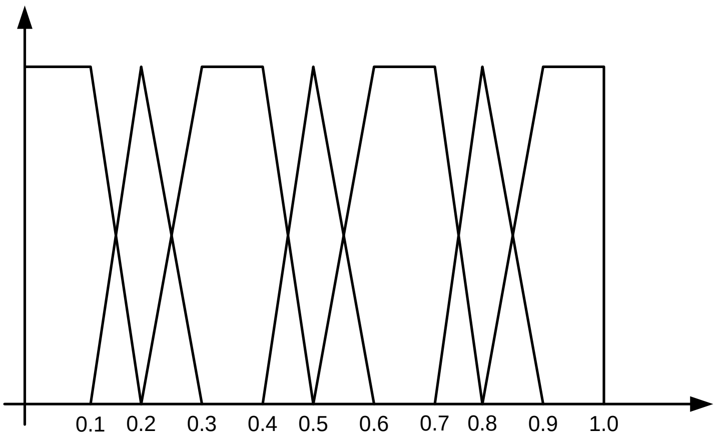

Figure 1. A triangular fuzzy numbers (Shiroye, 2013)

$$\mu R(M) = 1 - \frac{1}{1+a} * (1 - m) \quad (10)$$

$$\mu L(M) = 1 - \frac{1}{1+b} * (m) \quad (11)$$

$$A = \sum_j (Wj.Wij) \quad (12)$$

$$WSV = \sum D \times W \quad (13)$$

$$CI = \frac{\lambda \max - m}{m-1} \quad (14)$$

$$\hat{r}.j = \frac{1}{n}\sum_{i=1}^{n} rij \quad (15)$$

Using equation 15, the natural attribution of incompatibility can be figured out upon a matrix set for data in which λmax is always ≥ m. λmax and m are the biggest eigenvalue of the pairwise comparison and criteria number respectively. Therefore, $\lambda\max - m$ represents the incompatibility degree in the matrix. In the equation 16, the symbols of CI and RI are the consistency index and random index which Saaty (1980) used them for a matrix holding a set of data from 1 to 10 and recognized a compatibility value as CR ≤ 0.1. The incidence of random inconsistencies suggested by Saaty (1980) is according to Table 2.

Table 2. Incidence of random inconsistencies (Saaty, 1980)

m	1	2	3	4	5	6	7	8	9	10
RI	0.0	0.0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \quad (16)$$

$$\mathrm{Z\,x} = \lambda\max X \quad (17)$$

The current research, obtained data were the findings of Iranian evaluator team once prior to the implementation of the industries sites. Therefore, data are offered as a reference information and there is no possibility of changing data. Therefore, the conditions described in Equation 16 cannot be applied to the evaluation style of this research. The studies and assumptions mentioned by Saaty (1980) are governed by the questionnaire methods and if the results are not met the assumptions and conditions of the formula or any failure to follow the results with the assumptions and conditions needs modifying and changing even rechecking the privileges, scores and marks given by experts. Equation 17 is utilized to estimate the priority vectors so Z, x and max are the values of pairwise comparison matrix, priority vector or Principal Eigenvector and maximum or principal Eigenvalue of matrix Z (Shirazi et al., 2017; Shiroye, 2013).

3.3 Fuzzy TOPSIS procedure

Using the fuzzy TOPSIS method to extract the final weight of data, is a type of evaluation of matrix containing industries criteria in which aij is the numerical value of each industry i, according to the index j. TOPSIS method is a very strong evaluation method and a technique for prioritizing by analogy to the ideal response. Based on the fact that the selected option should be kept in the shortest distance from the ideal response and the furthest distance from the worst response. In this research, the TOPSIS method was selected based on Hwang's rule for choosing the best options. Equation 18 was used to convert the matrix of industries factors into a non-dimension matrix.

$$\mathrm{Nd} = \frac{\mathrm{aij}}{\sqrt{\sum_{i=1}^{m}(aij)^2}} \quad (18)$$

The next step was to create a non-dimension matrix with the assumption that the weights (Wn.n) are indexed. The non-dimension matrix is obtained by equation 19. Therefore, the special vector (obtained from the Friedman test) was conducted on a non-dimension matrix to get the values for V.

$$V = Nd \times Wn.n \quad (19)$$

The next step was to identify the ideal positive solution (A^+) and the ideal negative solution (A^-) according to the equations of 20 and 21. To perform this purpose the amounts were extracted based on equations at each column of V.

$$A+= \{(\max Vij | j \in J), (\min Vij | j \in j') | i = 1,2,\dots,m\} = \{V1+, V2+, .. Vj+, Vn+\} \quad (20)$$

$$A-= \{(\min \mathrm{i} Vij | j \in J), (\max Vij | j \in j') | i = 1,2,\dots,m\} = \{V1-, V2-, .. Vj-, Vn-\} \quad (21)$$

Then the distance between each option was calculated using Euclidean intervals according to equations 22 and 23. The relative proximity to the ideal solution was calculated in accordance with equation 24. On the other hand, equation 24 represents approach coefficient (Zagorskas et al. 2014; Nikas et al., 2018; Mukhametzyanov & Pamucar, 2018).

$$di+= \left\{\left(\sum_{j=1}^{n}(Vij - Vj +\right)^2\right\}^{0.5} \; ; i, = 1,2,3, \dots m \quad (22)$$

$$di-= \left\{\left(\sum_{j=1}^{n}(Vij - Vj -\right)^2\right\}^{0.5} \; ; i, = 1,2,3, \dots m \quad (23)$$

$$cli+= \frac{di-}{di(+)+(di-)} \quad (24)$$

4. Results and discussion

The wood was, at first, a vital ingredient for the construction of primary tools, homes and boats for moving in the rivers. Then, it was employed to make most of the useful things that people relied on for centuries to develop their lives style. Part of the technology of wood has left over by the efforts of industrialists, but most of it has been lost and replaced by other materials and methods that are the result of the industrial revolution of mankind. Wood is the only natural renewable resource. Oil and coal and other mines will eventually end, but a well-maintained forest will indefinitely continue to produce wood. Wood has a prominent place in the global economy. The annual production of wood in the world is 2,500 million cubic meters. The physical, chemical and mechanical properties of wood have made it a unique product for lots of applications at this time. Wood is one of the most useful materials we have which is sturdy, but it can be easily cut and made in different shapes. The bulk of wood comes from the trunk or body of trees. Wood hardness; this is important in the quality of work with those and other uses, such as parquet, which is continuously affected by wear. Softwoods are more likely to be consumed in carpentry. The impact resistance of wood is different because of the heterogeneous construction of wood in different directions and sizes. The wood in the direction of the impact has a lot of pressure, but it changes due to the introduction of a lot of force. Flexural Strength; the wood affected by bending is noticeably deformed. If the force applied is more than flexural, it will break the fibre. As the wet stick is more flexible, its resistance to impact is greater. In general, the more porous the wood is, the less the impact is. Wood durability; wood is not a durable object, it is worn out by insects and fungi. Of course, thicker wood is more durable and can be increased by some methods. Nowadays, there is a lot of consumption for wood in many other industries, including printing, chasing, furniture, carpentry, shoemaking, coiling, carving and railway wagoning, and many other industries, especially in the motherboard industry. Today, many products, such as a variety of compact fibres, bone fragments, chipboard, refractory boards, triplex and five-ply boards, and many others are used in machine systems, building and refurbishment work etc. Therefore, we tried to present wood applications and existing technologies to produce and make woody equipment. Our data were raw results of Iranian evaluator team once before construction of manufacturers in terms of energy consumed, input and output materials injected into generation process along with accessible facilities in each industry. Figure 2 shows the IWCI and their production processes and running technologies. Table 3 includes input materials entered to IWCI and Table 4 contains IWCI, number of staff, land area used and energy consumptions.

Up to down: Cooler bangs (1), Carton (2), Industrial drying wood (3), Hydrophilic cotton (4), Sheet rolls and packing (5), Wax paper (6), Booklet (7), Hasp (8), Decal (9), Multilayer paper bags (10), Row board (11), Wooden and paper disposable products (12), Wooden pencil (13), Carbon paper (14), Parquet (15), Sandpaper (16)

Figure 2. IWCI and their production processes

Table 3. Input materials entered to IWCI

Industry	Initial materials
(1)	Wood (1890t); Nylon networks (43260 kg); Packaging bags (9700 kg); Stapler needles (29120 bundle)
(2)	Three layers paper sheets (1454117 kg); Five layers paper sheets (955704 kg); Silicate glue (25498 kg); Dye (9956 kg); Nylon cords (1100 kg)
(3)	Wood pollens (9500 m^3)
(4)	Raw cotton (440t); Bleach with activity of 11-12 (55t); NaOH, 98% (17.6t); Washing liquid (4.4t); H_2SO_4 (4.4t); Nylon, thickness of 0.02 mm (40t); Softener (4.4t); Thiosulfate (8.8t)
(5)	Paper, 30 g/m^2 (947.5t); Three layers packaging cartons in sizes of 75*23*50 cm^3 (139000 No); Cardboard pipes, L= 23 cm (100t); Plastic bags (16.7t)
(6)	Paper rolls having 500 kg (685t); Al sheets, thickness of 10 micron (285t); Paraffin as rolls of 500 kg (52t); Special gum (3.1t); Packing paper (3.2t)
(7)	Paper of 60 g (379t); Cardboard, 175 g (43t); Plastic yarn (312000 g); Stapler wires (686 kg); Ink (22.8 kg); Cartons in sizes of 66*52.5*18 cm^3 (17333 No)
(8)	Timber (400 m^3); Timber layers of 2.5 mm (40000 kg); Formaldehyde jum 60% (8000 L); Glue (160 kg); Axe (60000 No); Spool 27-30 (15000 No); Brass pieces (15000 No); Paper washer (120000 No); Bolts and nuts (120000 No); Hasp bar (30000 No); Prong (30000 No); Nuts layout (120000 No); Polished oil (600 l); Thinner 2000 (200 l); Washing soap (400 kg); Nail with grade of 4 and 5 (100 kg)
(9)	Velvet and raw papers (6250000 No); Resin paste (312500 kg); Ink (800 kg); Resin glue (15625 kg)
(10)	Craft paper (2232t); Crepe paper (84t); Paper yarn (84t); filter cords as sweeper (18t); Gum, liquid silicate (180t); Ink (12t); PP strips, W= 2 cm (400000 m)
(11)	Wood veneer (126000 pieces); Urea glue (6300 kg); Filler and fixer pastes (8220 kg); Sandpaper (1260 m^2)
(12)	Dry wood (240000 kg); PE cover (27t); Nylon cover (20457 m^2); Plastic boxes (210000 No); Packaging carton (580 No); Tape (10000 m)
(13)	Slat in dimensions of 184*71*5.2 cm^3 (340200 No); Graphite of pencil (46638 No); Glue AW (6674.4 kg); Black dye (30034.8 kg); Other dyes (3337.2 kg); Al cellophone (2182 rolls); Boxes having 12 empty spaces (687204 rolls); Packaging cartons having 288 empty spaces (13772 rolls); Tape (1000 rolls)

Industry	Initial materials
(14)	Raw paper with width around 674 mm, length of 3000 m (1285 roll); Ink (36t); Ink of paper backside (26t); Carton with dimension of 100*105*88 cm^3 (4500 No); Boxes of 10*35*22 cm^3 (450000)
(15)	Oak pollen (4934 m^3); Paper sheet, W= 50 cm (157000 m^2); Carton in sizes of 49*49 cm^2 (25050 No); PP rope (5300 m); Glue materials (1500 kg)
(16)	AlO 93-98.5% (133000 kg); Formaldehyde urea gum (326000 kg); Craft paper (490000 kg); Wood ink (10200 kg); Gum (10200 kg)

W= width, L= length, PP= Polypropylene, PE= Polyethylene

Table 4. IWCI, numer of staff, land area used and energy consumptions

Industry	Nominal capacity (t)	Employees	Power (kw)	Water (m^3)	Fuel (Gj)	Land (m^2)
(1)	1400	29	125	10	3	9500
(2)	1500	20	100	5	3	3500
(3)	7500	24	174	12	29	5400
(4)	400	29	187	17	35	4000
(5)	1000	30	228	6	10	5800
(6)	1000	16	58	4	3	2400
(7)	2600000	30	174	12	29	2100
(8)	120000	10	212	10	23	4600
(9)	6250	23	116	7	7	4000
(10)	12000	35	155	8	7	5100
(11)	12000	72	575	20	25	15700
(12)	7565000	30	152	13	5	3300
(13)	324000	13	99	8	3	2100
(14)	450000 pockets	15	30	3	3	2100
(15)	150000m+150000 m^2	42	359	60	74	20600
(16)	2000000 m^2	20	209	12	31	7300

4.1 Delphi fuzzy set

SPSS Software, AHP and Fuzzy TOPSIS methods were assigned to classify around 16 IWCI. Using Friedman test the ranks values were obtained about 2.59, 4, 1.53, 1.88 and 5 for the number of employees, power, water, fuel consumed and land area. Tables 5 and 6 show Likert spectrum defined for criteria, Fuzzy set possessing values and linguistic words respectively.

Narimisa and Narimisa (2016) used paired comparisons matrix among main factors of Isfahan oil refinery so it resulted to a prioritization style as economic > land use > environmental > social. Azizi et al. (2009) assigned AHP and Expert Choice 2000 upon Iranian particle board industries among major criteria intensities, so results revealed that the density of the products and its high intensity had the highest priority. Azizi (2007) assessed Iranian facial tissue industries based on weighing factors via AHP method and Expert Choice software. It revealed that softness, time of absorption, appearance quality, basis weight and price criteria had high priority respectively.

Table 5. Criteria / symbols versus factors based on likert scale

Criteria / symbols	Employees	Power (kw)	Water (m^3)	Fuel (Gj)	Land (m^2)	Symbol
Very high	121-140	+600	+60	+ 250	16501-24000	VH
High	101-120	501-600	51-60	201-250	12501-16500	H
Slightly high	81-100	401-500	41-50	101-200	10001-12500	SH
Medium	61-80	301-400	31-40	76-100	7501-10000	M
Slightly low	41-60	201-300	21-30	51-75	5001-7500	SL
Low	21-40	101-200	11-20	26-50	2501-5000	L
Very low	0-20	0-100	0-10	0-25	0-2500	VL

Table 6. Fuzzy decision-making approach to prioritize the factors

Industry	Nominal capacity	Employees	Power	Water	Fuel	Land	Weights
(1)	1400	L (0.2272)	L (0.2272)	VL (0.1362)	VL (0.1362)	M (0.5)	4.46
(2)	1500	VL (0.1362)	VL (0.1362)	VL (0.1362)	VL (0.1362)	L (0.2272)	2.498
(3)	7500	L (0.2272)	L (0.2272)	L (0.2272)	L (0.2272)	SL (0.3695)	4.11
(4)	400	L (0.2272)	L (0.2272)	L (0.2272)	L (0.2272)	L (0.2272)	3.408
(5)	1000	L (0.2272)	SL (0.3695)	VL (0.1362)	VL (0.1362)	SL (0.3695)	4.37
(6)	1000	VL (0.1362)	VL (0.1362)	VL (0.1362)	VL (0.1362)	VL (0.1362)	2.043
(7)	2600000	L (0.2272)	L (0.2272)	L (0.2272)	L (0.2272)	VL (0.1362)	2.95
(8)	120000	VL (0.1362)	SL (0.3695)	VL (0.1362)	VL (0.1362)	L (0.2272)	3.431
(9)	6250	L (0.2272)	L (0.2272)	VL (0.1362)	VL (0.1362)	L (0.2272)	3.097
(10)	12000	L (0.2272)	L (0.2272)	VL (0.1362)	VL (0.1362)	SL (0.3695)	3.8
(11)	12000	M (0.5)	H (0.7727)	L (0.2272)	VL (0.1362)	H (0.7727)	8.85
(12)	7565000	L (0.2272)	L (0.2272)	VL (0.1362)	VL (0.1362)	L (0.2272)	3.097
(13)	324000	VL (0.1362)	VL (0.1362)	VL (0.1362)	VL (0.1362)	VL (0.1362)	2.043
(14)	450000 pockets	VL (0.1362)	VL (0.1362)	VL (0.1362)	VL (0.1362)	VL (0.1362)	2.043
(15)	150000m+150000 m2	SL (0.3695)	M (0.5)	H (0.7727)	SL (0.3695)	VH (0.8636)	9.15
(16)	2000000 m2	VL (0.1362)	SL (0.3695)	VL (0.1362)	L (0.2272)	SL (0.3695)	4.31

4.2 Fuzzy TOPSIS procedure

Using equation 18 the existing data in Table 6 were shifted to present data of Table 7. In the following was used equations of 19-24 to obtain Fuzzy TOPSIS values and their weights according to Table 8.

Table 7. Defuzzification matrix

Industry	Nominal capacity (t)	Employees	Power	Water	Fuel	Land
(1)	1400	0.25	0.174	0.1362	0.184	0.318
(2)	1500	0.15	0.104	0.1362	0.184	0.144
(3)	7500	0.25	0.174	0.2272	0.307	0.235
(4)	400	0.25	0.174	0.2272	0.307	0.144
(5)	1000	0.25	0.284	0.1362	0.184	0.235
(6)	1000	0.15	0.104	0.1362	0.184	0.086
(7)	2600000	0.25	0.174	0.2272	0.307	0.086
(8)	120000	0.15	0.284	0.1362	0.184	0.144
(9)	6250	0.25	0.174	0.1362	0.184	0.144
(10)	12000	0.25	0.174	0.1362	0.184	0.235
(11)	12000	0.549	0.174	0.2272	0.184	0.492
(12)	7565000	0.25	0.174	0.1362	0.184	0.144
(13)	324000	0.15	0.104	0.1362	0.184	0.086
(14)	450000 pockets	0.15	0.104	0.1362	0.184	0.086
(15)	150000m+ 150000 m^2	0.4056	0.384	0.7727	0.5	0.55
(16)	2000000 m^2	0.25	0.284	0.1362	0.307	0.235

Ideal and anti-ideal solutions in the TOPSIS procedure were complied from the obtained values for A^+ and A^- that in the following has been explained; A^+= 1.42, 1.536, 0.347, 0.94, 2.75 and A^- = 0.388, 0.416, 0.208, 0.345, 0.43. Based on ideal and anti-ideal amounts were computed di^+ and di^- and also cli^+.

In lots of researches, AHP is applied to extract weights for criteria, while Fuzzy TOPSIS employed to support the ranking of options. Mardani et al. (2016) evaluated around 10 biggest Iranian hotels via fuzzy set theory in different provinces focusing on prominent key energy-saving technologies and solutions. So, 17 key energy factors were chosen in the first screening among about 40 energy factors classified into 5 groups. Findings revealed rank ratios around 0.403, 0.225, 0.151, 0.091 and 0.083 for the equipment efficiency, system efficiency, heating and cooling demands reductions, energy management and renewable energy respectively. The fuzzy AHP among 17 factors presented ranks around 0.662, 0.541 and 0.532 for active space cooling, building insulation and tourist accommodation service respectively.

Table 8. Fuzzy TOPSIS values and their weights

Industry	Nominal capacity (t)	Employees	Power	Water	Fuel	Land	di+	di-	cli+
(1)	1400	0.647	0.696	0.208	0.345	1.59	1.7369	1.2210	0.412
(2)	1500	0.388	0.416	0.208	0.345	0.72	1.744	0.29	0.142
(3)	7500	0.647	0.696	0.347	0.577	1.175	1.97	0.88	0.308
(4)	400	0.647	0.696	0.347	0.577	0. 72	2.357	0.55	0.189
(5)	1000	0.647	1.136	0.208	0.345	1.175	2.12	1	0.31
(6)	1000	0.388	0.416	0. 208	0. 345	0.43	2.78	0	-
(7)	2600000	0.647	0.696	0.347	0. 577	0.43	2.610	0.218	0.77
(8)	120000	0.388	1.136	0. 208	.0 345	0. 72	2.391	0.77	0.24
(9)	6250	0.647	0.696	0. 208	0. 345	0. 72	2.4	0.48	0.16
(10)	12000	0.647	0.696	0. 208	0. 345	1.175	2.038	0.7	0.255
(11)	12000	1.42	0.696	0. 347	0. 345	2.46	1.069	2.3	0.683
(12)	7565000	0.647	0.696	0. 208	0. 345	0. 72	2.407	0.48	0.166
(13)	324000	0.388	0.416	0. 208	0. 345	0.43	2.78	0	-
(14)	450000 pockets	0.388	0.416	0. 208	0. 345	0.43	2.8	0	-
(15)	150000m+ 150000 m2	1.050	1.536	0. 347	0.94	2.75	0.37	2.73	0.88
(16)	2000000 m2	0.647	1.136	0. 208	0. 577	1.175	1.840	1.090	0.37

Yazdani-Chamzini et al. (2013) used Fuzzy TOPSIS to assess the problem of investment strategy selection. The fuzzy TOPSIS methodology applied for prioritizing the existing alternatives. The findings offered that the implemented model has a high potential to evaluate the data. Zagorskas et al. (2014) studied the growth in building refurbishment of new-build projects and historical buildings preservation involvements in terms of practice for assigning best insulation options. According to the research, 5 modern insulation materials had chosen and evaluations revealed that TOPSIS technique with grey numbers was a dominant technique to realize. Nikas et al. (2018) evaluated the gap between climate policy to find a methodological framework and remove existing complex problems using both Delphi and TOPSIS methods. By the way, they reached to find ranks for factors and criteria and closeness to ideal solutions. Cavallaro et al. (2016) studied a prioritization method for factors and criteria of combined heat and power systems via Fuzzy Shannon entropy and Fuzzy TOPSIS. Findings represented a classification as Turbine > steam turbine > fuel cell > reciprocating engine > micro-turbine. Moghimi and Anvari (2014) employed Fuzzy MCDM approach among 8 Iranian cement companies listed in the Tehran Stock Exchange based on financial statements. Hence, the ranking of companies has done as Sabhan, Sarab, Sedasht, Safar, Sekaroun, Sakarma, Sanir and Sahrmoz with priority scores of 0.55, 0.51, 0.50, 0.49, 0.42, 0.37, 0.36 and 0.33 respectively. Radfar and Ebrahimi (2012) used Fuzzy multi-criteria decision making for Iranian shipping industries to prioritize the investment methods in technology transfer. Obtained results led to introduce Joint venture and the subsidiary companies as the highest and lowest priorities, respectively. Parsa et al. (2016) utilized Fuzzy TOPSIS technique for National Iranian Gas Company to evaluate performance. It was performed a scoring and ranking system among them. Sorayaei et al. (2012) used a Fuzzy network model for forecasting stock exchange of the automobile industries. So, the results indicated the bubble growth of stock exchange of Iran automobile industries. Kavousi and Salamzadeh (2016) applied TOPSIS technique for National Iranian Copper Industries to identify and prioritize factors influencing the success of a strategic planning process. In the following steps, indicators were weighted and prioritized. Ebrahimnejad et al. (2008) asserted his findings by Fuzzy Build - Operate - Transfer + MADM in order to evaluate Iranian Power Plant Industry in terms of risk identification and management. Therefore, a new ranking model was presented based on fuzzy. Tash and Nasrabadi (2013) exploited Fuzzy TOPSIS for ranking of Iran's Monopolistic Industry. Behrouzi et al. (2011) investigated 133 automotive industries using Fuzzy MADM + SPSS analysis in order to performance measurement. The classifying options, weighting and ranking systems were the prominent findings of this research. Zare et al. (2016) employed Fuzzy TOPSIS by using the nearest weighted interval approximations for the Aluminum waste management system selection problem. By the way, a few scenarios introduced to figure out the solutions, so scenarios were ranked based on their closeness coefficient to the ideal solution. Therefore, scenario of S_4 was distinguished as the most prominent practice with a weight of 0.723514 and then following scenario of S_1 with a value of 0.448137, scenario S_5 with a value of 0.354226, scenario S_2 with a value of 0.314215 and scenario S_3 with a value of 0.204909 were ranked from second to fifth as an overwhelming method to compute and prioritize factors respectively.

4.3 TOPSIS Method

In this step same procedure was done on data to classify IWCI. The difference between this method and the previous one was the use of real data for industries classification. Therefore, the existing data (in Table 4) were shifted to Table 9 and then to Table 10 using the equation of 18-24.

Table 9. Matrix based on (real data) in Table 4

Industry	Nominal capacity (t)	Employees	Power	Water	Fuel	Land
(1)	1400	0.235	0.140	0.136	0.029	0.3
(2)	1500	0.162	0.112	0.068	0.029	0.110
(3)	7500	0.195	0.195	0.164	0.279	0.170
(4)	400	0.235	0.209	0.232	0.337	0.126
(5)	1000	0.243	0.255	0.082	0.096	0.183
(6)	1000	0.13	0.065	0.054	0.028	0.075
(7)	2600000	0.243	0.195	0.164	0.279	0.066
(8)	120000	0.08	0.237	0.136	0.221	0.145
(9)	6250	0.186	0.13	0.095	0.067	0.126
(10)	12000	0.283	0.173	0.109	0.067	0.161
(11)	12000	0.583	0.644	0.273	0.24	0.496
(12)	7565000	0.243	0.170	0.177	0.048	0.104
(13)	324000	0.105	0.110	0.109	0.028	0.066
(14)	450000 pockets	0.121	0.033	0.041	0.028	0.066
(15)	150000m+150000 m^2	0.340	0.402	0.82	0.713	0.651
(16)	2000000 m^2	0.162	0.234	0.164	0.298	0.231

Table 10. TOPSIS values

Industry	Nominal capacity (t)	Employees	Power	Water	Fuel	Land	di+	di-	cli+
(1)	1400	0.60865	0.56	0.2080	0.5452	1.5	3.111	1.4	0.310
(2)	1500	0.41958	0.448	0.10404	0.05452	0.55	4.087	0.0.44	0.099
(3)	7500	0.50505	0.78	0.25092	0.52452	0.85	3.412	1.16	0.254
(4)	400	0.60865	0.836	0.35496	0.63356	0.63	3.47	1.17	0.252
(5)	1000	0.62937	1.02	0.12546	0.18048	0.915	3.36	1.25	0.27
(6)	1000	0.3367	0.26	0.08262	0.05264	0.375	4.25	0.189	0.040
(7)	2600000	0.62937	0.78	0.25092	0.52452	0.33	3.77	0.92	0.196
(8)	120000	0.2072	0.948	0.20808	0.41548	0.725	3.56	0.986	0.216
(9)	6250	0.48174	0.52	0.14535	0.12596	0.63	3.85	0.57	0.129
(10)	12000	0.73297	0.692	0.16677	0.12596	0.805	3.57	0.91	0.202
(11)	12000	1.51	2.576	0.41769	0.4512	2.48	1.5	3.547	0.7
(12)	7565000	0.62937	0.68	0.27081	0.09024	0.52	3.8	0.747	0.165
(13)	324000	0.27195	0.44	0.16677	0.05264	0.33	4.182	0.412	0.09
(14)	450000 pockets	0.31339	0.132	0.06273	0.5264	0.33	4.24	0.486	0.102
(15)	150000m+150000 m^2	0.8806	1.608	1.2546	1.34044	3.255	1.155	3.775	0.765
(16)	2000000 m^2	0.41958	0.936	0.25092	0.56024	1.155	3.146	1.27	0.287

Ideal and anti-ideal solutions in current TOPSIS procedure were complied from the obtained values for A^+ and A^- as; A^+= 1.51, 2.576, 1.2546, 1.34044, 3.255 and A^- = 0.2072, 0.132, 0.06273, 0.05264, 0.33. Finally, IWCI was classified based on 3 methods of Fuzzy Set Logic, Fuzzy TOPSIS, TOPSIS based on real data as below:

Fuzzy Set Logic: 15 > 11 > 16 > 5 > 1 > 3 > 10 > 4 > 8 > 7 > 9 = 12 > 2 > 6 > 13 = 14;

Fuzzy TOPSIS: 15 > 7 > 11 > 1 > 5 > 16 > 3 > 10 > 8 > 4 > 12 > 9 > 2 >; (6=13=14);

TOPSIS: 15 > 11 > 1 > 16 > 5 > 3 > 4 > 8 > 10 > 7 > 12 > 9 > 14 > 2 > 13 > 6

Further study on the industries of IWCI was revealed the statistics and list of facilities and equipment used according to Table 11. Awareness of the existing facilities in IWCI helps stakeholders to understand new developments in utilized facilities. Also, the information provided can be compared with the facilities and equipment industries in other countries.

Table 11. All available facilities of IWCI

Industry	Facilities
(1)	Saw, 500 kg/h, 15 hp (1 No); Bangs producer machine, 260 kg/h, 15 hp (1 No); Baling machine, 8 tons/h, 2.5 hp (1 No)
(2)	Lining machines, 10 and 14 m2/min (1 and 1 No); Cutting machine, 170 m/h, 4 kw (1 No); Dye cast machine (1 No); Split machines, 10 m2/min; Saw, 3 kw, 30 m/min (3o No); Print machine, 3.5 kw (1 No); Carton maker machine, 2000 cartons/h, 3 kw (1 No); Packaging machine (1 No)
(3)	Motor saw of 590 degree, (1 No); Saw with w= 140 cm, 30 kw (1 No); Saw 100, 15 kw, 1500 rpm (2 No); Cutting machine, 5 kw, 1440 rpm (1 No); Grinder, 5 kw (1 No); Dryer machines (3 No); Wagons, in size of 1.5*3 m2 (48 No); Derrick, 5 ton (2 No); Compressor, 110 atm, 2000 L, 7 kw, 4 m3/min (1 No)
(4)	Cleaning machine, 130 kg/h, 4 kw (1 No); Block machine (1 No); Cotton baking pot, 125 kg/h, 35 kw (1 No); Feeding tank (1 No); Centrifuge, 130 kg/h, 5 kw (1 No); Dryer, 300 kg/h, 25 kw (1 No); Wraping machine, 150 kg/h, 5 kw (1 No); Carding machine, 60 kg/h, 5 kw (1 No)
(5)	Cutting and perforation machine, 5 kw, 10 kg/min (1 No); Rolling machine, 8 kw, 4.5 kg/min (8 No); Air suction fan, 2 kw (2 No); Fitted lab (1 No)
(6)	Roll flattening machine (1 No); Gluing machine (1 No); Printing machine (1 No); Paraffin addition machine (1 No); Cutting machine (1 No); Derrick, 2 tonss (1 No)
(7)	Cutting machine, 5 kw (1 No); Stapler machine, 0.6 kw (2 No); Labelling machine, 1.5 kw (1 No)
(8)	Shaver, 5 kw (1 No); Saw, 11 kw (1 No); Saw sharpener, 1.5 kw (1 No); 5-Storeys thermal press, 20 kw (2 No); Boiler, 0.5 ton, 2 kw (1 No); 5-ways device, 2.5 kw (1 No); Perforating machine, 2.5 kw (1 No); FS 1000 machine, w= 1000 mm (1 No); Automat sewing machine, 7 kw (1 No); Rond sanding, 2 and 3 kw (1 and 1 No); Cutting machine, 3 kw (1 No); Tape buffing machine, 4 kw (1 No); Polishing machine, 4 kw (1 No); Drill 1.5 kw (2 No); Gum roller and mixer, 5 kw (1 No)

(9)	Steel mixing tanks, 1 ton (2 No); Printing machine, 2 m/min (1 No); Drying and flocking machines, 500 kg (1 No); Fluff removal machine, 5 m/s (2 No); Screen printing machines, 1 m/min (6 No); Sheet dryer machine, 2 m/min (30 No); Printing machines, 3 m/min (2 No); Flattening machine, 2 m/min (1 No); Al frames (500 No); Cleaner along with plastic knive (1 No)
(10)	Envelope manufacturing machine, L and w= 5-110 cm and 35-60 cm (1 No); Two-sided sewing machine, L= 65-95 cm, capacity of 1500 No/h (2 No); One-sided sewing machine, L= 65-90 cm, capacity 1500 No/h (2 No); Packaging machine, in bundles of 100-150, 50 No/h (2 No); Gum dough generation device, 1 ton (1 No); Feeding roll paper, 50 m/min (1 No); Compressor, 7-10 kg/cm2 (1 No); Testing and checking equipment (1 No); Repair workshop (1 No)
(11)	Derrick, 5 tons (1 No); Automatic saw, 48, 38 and 42 inch (1, 1 and 4 No); Circular conveyor, L= 3 m (10 No); Circular saw, 40 inch (2 No); Dryer furnace, model of 10 m BMF-KIN (8 No); Derrick, 2 tons (1 No); Cutting saw (5 No)
(12)	Primary wood Cutting machine, 28 inch, 2.5 kw, 5 tons (2 No); Secondary wood cutting machine, I 3 model, w= 100 mm, 35 rpm, 30 kw (2 No); Low-diameter round timber manufacturing machine, K 20.2, w= 80 mm, d= 80 mm, 20 rpm, 5 kw, weight of packs 550 kg (1 No); Wood cutting machine of AZ-2.5, 3 KW, weigh of packs 50 kg (1 No); Wood thickness setting machine, 6 kw, weigh of pack 60 kg (1 No); Cutting machine with circular saw, MU-VS 3, 2 KW, weigh of pack, 120 kg (1 No); Polishing machine, Pot 1000 model, 0.5 kw, 20 rpm (1 No); Packaging machine, 10.5 hp, 3 kw, pure weigh of 10 kg (1 No); Paper milling machine, Ramonas model, 3 tons, 14-18 kw (1 No)
(13)	Complete line of wooden pencil production, 1200 tablet/shift, 28.5 kw (1 No); Cyclone along with centrifuge machine, steel carbon, d and h= 68 and 1000 mm (1 No)
(14)	Printing press machine, 100 m/min (1 No); Roll flattening machine, 30-160 m/min (1 No); Gillutine 34 rpm (1 No); Lab and repair workshop (1 and 1 No)
(15)	Semi automatic saw, 5.5 and 11 kw (1 and 3 No); Saw for cutting dry boards (2 No); Multi-saw machine (1 No); Automatic grinder, 7.5 kw (2 No); 15-saws machine, 15 kw (1 No); Finishing operation line such as buffing and dyeing operations (1 No); Wood carving machine, 63 cm, 5.5 kw (1 No); Curing machine, 70 cm, 5.5 kw (1 No); Saw A80, 6 kw (1 No); Automatic packaging machine (1 No); Dye drying line (1 No)
(16)	Spray system as electrostatic and gravity (1 No); Heating and ventilation as tunnel dryer (1 No); Preparation section for resin and gum (1 No); Motive power (1 No)

W= width, L= length

4.4 Statistical analysis results

T-test analysis had represented significant differences around (p-value≤ 0.001, 0.002 among the main criteria of IWCI such as the number of employees, power, water and fuel consumptions and the land area occupied by each industry. Pearson correlation sig. (2-tailed), Kendall's correlation coefficient sig. (2-tailed) and

Spearman's correlation coefficient analysis had manifested the highest significant differences about 0.886, 0.653 and 0.820 between both factors of fuel and water consumptions respectively. The categories of water, fuel, power consumptions, number of employees and the land area used had shown equal probabilities around 0.982, 0.437 (via one-sample Chi-Square test), 0.299 (via one-sample Kolmogorov Smirnov test) and 0.309 and 0.185 (via one-sample Kolmogorov Smirnov test). Therefore, the Null hypothesis was retained among factors. Kolmogorov – Smirnov Z was conducted to figure out normal distribution among factors so obtained results revealed values about 0.966, 0.974, 1.243, 0.907 and 1.090 for the number of employees, power, water, fuel consumed and the land area occupied by industries individually. Therefore, the obtained findings have supported the presence of a normal distribution trend among factors. Hassanpour (2017) investigated 6 different kinds of Iranian recycling industries comprising factors of power-water and fuel-land with a result as ($p_{value} \leq .016$ and 0.023) via SPSS analysis respectively. Unnisa & Hassanpour (2018) came into view a significant difference among factors such as initial feed, employees, power, water, fuel and land ($p_{value} \leq .001$) in an assessment upon 4 various kinds of Iranian brick manufacturing industries.

5. Conclusion

By present study was empirically assessed IWCI in terms of an inventory of materials, processes and facilities employed. Data were evaluated by three methods of Delphi logic, Fuzzy TOPSIS, TOPSIS along with SPSS analysis of data. It was found that TOPSIS (based on real data) was more precise than Fuzzy TOPSIS and Delphi Fuzzy set to classify industries. The SPSS software presented correlations, significant differences and Null hypothesis among the data to complete IWCI evaluation procedure. Some of the main achievements of this study can be cited to awareness of the flow of input materials injected into industries according to the type of materials and their required values, the prediction of the type of pollutants released into the environment and developing researches towards industrial ecology studies, the identification of existing facilities and devices in the industries and as well as technologies employed for the purposes of industry 4.0, getting enough knowledge about the amount of energy consumed in industries and the amount of product produced by each industry, providing economic estimates of industries in the easiest possible way, managing industries regarding the enough information to evaluate efficient industries in studies related to data envelopment analysis etc.

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