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A Fuzzy-AHP Method for Selection Best Apparel Item to Start-Up with New Garment Factory: A Case Study in Bangladesh

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A B S T R A C T

The readymade garments industry is rapidly growing and now it is the single highest export earner for Bangladesh. This business sector becomes an attractive investment destination to the country's new young entrepreneurs upcoming due to its cheaper labor cost, lower investment cost, availability of resources, governments support, etc. than the other sectors. However, many other factors are often needed to consider in investing in this garments sectors. Again, in garments sectors, there is a wide range of apparel items like shirts, trousers, jackets, sweaters, etc. options that are available to invest. Different types of apparel items demand different types of resource requirements, diverse level of capital investment, operator's skills, and it is also related to the many other factors. Again, all the investors are not in same stand points according to their business handling capabilities, capitals in hand, business locations and so many other aspects. This paper proposes a methodology for selection best apparel item among different alternatives that will provide a decision support to the investors in opening a new garment factory. The proposed methodology is based on Analytical Hierarchy Process (AHP) under fuzzy environment. The approaches allow the decision maker to use expert's judgment in the form of linguistic expression in the evaluation process. In the application of proposed methodology, the best apparel item is selected for opening a garment factory in Bangladesh at present conditions.

Keywords: Fuzzy-AHP, Multi-criteria decision making, Garments, Product prioritization.

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1. Introduction

In Bangladesh, the name of the garment industry comes first as a leading manufacturing industry among all the export oriented industries. This sector has provided employment to over 4 million, which most of them are women, and utterly transformed the economic and social landscape of the country. Since 45 years of independence, the poverty rate has been decreased from 80 percent down to less than 26 percent today; GDP growth has been averaged around 6 percent for over 10 years, and the garment industry has had a lot to do with it. In recent years, the garment sector has

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emerged as the biggest earner of foreign currency and highest contributor in the GDP of the country. There are many factors, which make this sector as an attractive investment destination: cheaper labor cost, huge skilled manpower, government supports, Foreign Direct Investment (FDI), etc. Every year in Bangladesh, a number of new factories are being set-up. According to the Bangladesh Garments Manufacturing and Exporter's Association (BGMEA), the number of factories from fiscal year 2005-06 to 2016-17 are given in Table 1 and Figure 1. It is seen that the number of factories has been increased each successive fiscal year with increasing rate of around 5 percent except the fiscal year 2013-14. In that years, this industry faced some unexpected incidence like Rana plaza collapse, fire at Tazreen fashion ltd, etc. However, to overcome those problems, this sector has been able to continue its progress again. A notable section of country's young generation is being motivated and coming to invest in this sector every year.

Table 1. A brief overview of garments industry in Bangladesh, Source: BGMEA, Bangladesh.

Fiscal Year	Number of Garments Factory	Total export in MN.US$
2005-06	4220	7900.80
2006-07	4490	9211.23
2007-08	4743	10699.80
2008-09	4925	12347.77
2009-10	5063	12496.72
2010-11	5150	17914.46
2011-12	5400	19089.73
2012-13	5876	21515.73
2013-14	4222	24491.88
2014-15	4296	25491.40
2015-16	4328	28094.16
2016-17	4482	28149.84

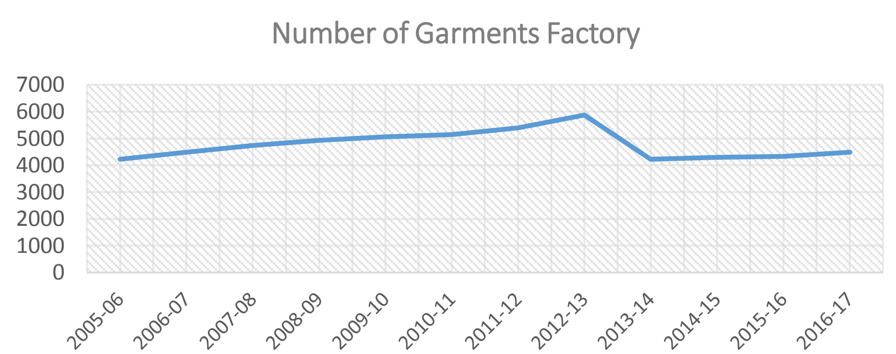

Figure 1. Number of garments factory increased over the fiscal year.

There are many product categories in this sector such as shirt, T-shirt, trousers, sweaters, etc. Table 2 shows the major apparel items that are exported from Bangladesh last five consecutive years. All the items contribute significantly in foreign earning.

Table 2. Major apparel items exported from Bangladesh in Million USD.

Year	Shirts	Trousers	Jackets	T-shirts	Sweaters
2010-2011	1566.42	4164.16	1887.50	4696.57	2488.19
2011-2012	1733.54	4686.39	2231.16	4713.11	2340.34
2012-2013	1972.89	5185.48	2634.28	5143.22	2620.73
2013-2014	2173.73	5690.78	2973.16	5863.81	2932.94
2014-2015	2271.43	5697.83	3183.17	6064.13	2829.16

It has been noticed that for being a large job markets and getting some works experiences, the young entrepreneurs are going to open their own new factory with their respective acquired skills. However, before opening new factory, it is quite important to decide what categories of product should be chosen for achieving higher profitability and sustainability. Since there is no enough opportunity to train up young entrepreneurs, which starting with their acquired little knowledge from work experiences often lead to poor performance. Many of them fail to sustain in the competitive environments because of their knowledge limitations, lower capital solvency, resources related problems, etc. Note that starting a factory with different item requires different types of resources, manpower skills, capital requirements, etc. Therefore, selection of right item from their individual's standpoint of knowledge, money, area, etc. may be the key to success in this sector. There is a need for developing a methodology, which will provide better decision supports in selecting apparel item.

This research intends to develop a methodology to find out best apparel item for starting up a new factory from individual standpoints. This method will provide decision supports to the new investors, which may be helpful in sustaining and progressing in this business sector. At that situation, MCDM method based on linguistic evaluations like AHP may help to make a better decision. This paper proposes a fuzzy-based AHP methodology for selecting best apparel item. The evaluation is not an exact process and has fuzziness in its body. For this reason, fuzzy logic is combined with AHP, and the usage of FAHP weights makes the application more realistic and reliable. The rest of paper is organized as follows: Section 2 describes literature review in the relevant topics with their limitations. In Section 3, theoretical frameworks have illustrated based on which a case study on apparel item selection that is described in Section 4. Results, discussions, and conclusions have described in Section 5 and 6, respectively.

2. Literature Review

In today's competitive era, people often face problems in decision making whether in business or in personal spheres. People need a systematic and comprehensive approach that will provide more effective decision support when any decision problems arise into them [1]. In the literature, there exists many multi-criteria decision making methods such as AHP, ANP, VIKOR, PROMETHEE, ELECTRE, GRA, TOPSIS, etc. [2].

The Analytic Hierarchy Process (AHP) is the most common multi-criteria decision-making method and was first introduced by Saaty in 1977 [3, 4]. The AHP has achieved attraction of many researchers mainly because of the precise mathematical properties, and the required input data are comparatively easy to obtain. Basically, it uses informed judgment or expert opinion to determine the relative value or contribution of these attributes and synthesize a solution. Although the Conventional AHP [10] is powerful in extracting the expert's knowledge, it still cannot reflect the human thinking style, as precise data concerning human attributes are quite hard to be extracted [10]. For example, the AHP method does not take into account the uncertainty associated with the natural language in the mapping of human judgment into a crisp number [11]. Therefore, fuzzy AHP, a fuzzy extension of AHP, was developed to solve the hierarchical fuzzy problems. In the fuzzy AHP procedure, the pairwise comparisons in the judgment matrix are fuzzy numbers. Therefore, that, the decision maker can specify preferences in the form of natural language expressions about the importance of each criterion [12]. Thus, Fuzzy logic offers a systematic base in dealing with situations, which are ambiguous or not well defined [13].

Fuzzy AHP (FAHP) is a synthetic extension of classical AHP method, which considers the fuzziness (uncertainty or insufficient information) of the decision makers. Because of having huge application area, FAHP approach has become a sensational research subject for many different field researchers. Fuzzy-AHP approach has been effectively applied in various applications, e.g. supplier selection [7, 28, 29, 30, 31], personnel selection [32], measuring instrument selection [20], job selection [33], project selection [34, 35], producer selection [36], construction project management selection [37] and many others. Fuzzy multiple attribute decision-making methods have been developed due to the imprecision in assessing the relative importance of attributes and the performance ratings of alternatives with respect to attributes [5]. There are varieties of reasons that may arise imprecision: unquantifiable information, incomplete information, unobtainable information, and partial ignorance. Conventional multiple attribute decision-making methods cannot overcome these problems effectively [2]. Basically, Fuzzy-AHP method represents the elaboration of a standard AHP method into fuzzy domain by using fuzzy numbers for calculating instead of real numbers [9]. The Analytic Hierarchy Process (AHP) is a powerful and flexible decision-making process [10] to help decision-makers providing the best decision when both qualitative and quantitative aspects of decision problems are needed to be considered.

As the nature of the human being, values of linguistic terms vary from person to person. In these circumstances, considering the fuzziness provides less risky decisions [20]. Since the uncertainty and vagueness of the expert's opinion is the prominent characteristic of a problem; impreciseness of human's judgments can be handled through the fuzzy sets theory developed by Zadeh [21]. According to Bellman and Zadeh [22], to deal with the kind of qualitative, imprecise information or even ill structured decision problems, fuzzy set theory can be used as modeling tool for complex systems that can be controlled by humans but are hard to define exactly [22]. Despite the convenience of AHP in handling qualitative and quantitative criteria of multi-criteria decision-making problems based on decision maker's judgments, the fuzziness and vagueness existing in many decision-making problems may contribute to the imprecise judgments of decision-makers in conventional AHP process [23]. The use of triangular membership functions for pairwise comparison scale of fuzzy AHP and the use of extent analysis method for synthetic extent value of the pair wise comparisons is considered a new approach for handling AHP [24].

Chang proposed method using fuzzy numbers as elements of comparison matrices in his work but the main problem was to compute the fuzzy weights as eigenvectors of these matrices [15]. Since fuzzy weights are not so easy to compute as like as crisp ones. Wang and Chin developed the Fuzzy Preference Programming (FPP) based on nonlinear method for the simplicity fuzzy AHP weight derivation [16]. In this work, they used logarithm scale to measure relative weights in pairwise comparisons more precisely. Besides these works, many authors combined AHP and fuzzy AHP with other methods of MCDM, such as TOPSIS and fuzzy TOPSIS [17, 18, 19]. In these cases, fuzzy AHP is used to determine the relative weights of two levels of criteria evaluation and after that, the fuzzy TOPSIS is used to rank the alternatives. Different researchers used Fuzzy-AHP methods in different area of decision-making problems combining with many other methods. Cheng [25] and Cheng et al. [26], evaluated naval tactical missile systems and attack helicopter, respectively by fuzzy AHP based on the grade value of membership function [25, 26]. Ruoning and Xiaoyan extent AHP method under fuzzy environment using linguistic term to express values [27]. Ayhan conducted a research on gear motor company to select the optimal supplier, which were evaluated under multiple criteria, such as quality, price, reputation, etc. [31]. Saad et al. used Fuzzy-AHP to select best procurement process [33]. Kwong and Bai combined Quality Function Deployment (QFD) and Fuzzy-AHP methods to prioritize customer requirements [43]. Hadad and Hanani proposed a methodology to find out best alternative merging two popular methods: AHP and Data Envelopment Analysis (DEA) methods [45].

The main objective of this research is to prioritize apparel items to start up a garments factory using Fuzzy-AHP approach. Literature review section investigates various research works relevant to this research. Many researchers have conducted their researches using Fuzzy-AHP method and revealed how this approach works and how effective is this approach in case of selection of best alternative among multiple choices. Although there is extensive volume of work on fuzzy-AHP methods in literature now, none of these methods takes into account the decision, which is associated with apparel item selection for starting new factory. In this paper, a fuzzy-

AHP based multi-criteria decision- making procedure is suggested for selecting most appropriate apparel item to start-up with new factory. For this aim, four main criteria are considered and five different alternatives are evaluated to determine the best apparel item to start-up business in garments sector.

3. Theoretical Framework

3.1. Classical AHP Methodology

The AHP is a mathematical model for the practical solution of many ranking problems in different areas of human interests [25]. It was developed by Saaty in the 1970s and has been extensively studied and refined since then. The main focus point of the AHP methodology considers the various phases of the process and presents an efficient outcome [38]. AHP breaks down a complex problem into measurable criteria in a hierarchical structure. AHP is structured for solving unstructured problems in economics, social and management science [2]. AHP has been applied in an exceedingly form of contexts from the simple everyday problem of choosing a school to the designing complicated issues of different future outcomes of a developing country, evaluating political candidature, allocating energy resources, and so on. AHP determines the weights of both qualitative and quantitative criteria [39]. The decision maker creates pairwise comparison matrix for every pairwise item assessed [40].

To make a decision in an organized way to generate priorities according to Saaty [40], we need to decompose the decision into the following steps:

- Identify the problem and determine the kind of knowledge sought.
- Structure the decision hierarchy from the top with the goal of the decision and the objectives from a broad perspective through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
- Constitute a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
- The priorities obtained from the comparisons are used to weight the priorities in the nearly lower level. Do this for every element. Then for each element in the level below add its weighted values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives at the bottom most level is executed.

3.2. Fuzzy Sets and Fuzzy Numbers

The concept of fuzzy logic was suggested by Zadeh [21] to formulate conclusions from vague, suspect or imprecise information. To explain this information in mathematics, a fuzzy set, which is a class of objectives with continuum grades of membership was developed. A membership function in fuzzy sets assigns to each object a grade of membership in [0, 1].

A tilde ‘‘~’’ will be placed above a symbol if the symbol represents a fuzzy set. A Triangular Fuzzy Number (TFN), $\tilde{M}$ is shown in Figure 2. A TFN is denoted simply as (l, m, u). The parameters l, m, and u denote the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event [4]. When $l = m = u$, it is a non-fuzzy number by convention [6, 7]. Each TFN has linear representations on its left and right side such that its membership function can be defined as [4]:

$$\mu_{\tilde{M}} = \begin{cases} 0, x < 1, \\ (x-l)/(m-l), \ l \le x \le m, \\ (u-x)/(u-m), m \le x \le u, \\ 0, x > u. \end{cases} \quad (1)$$

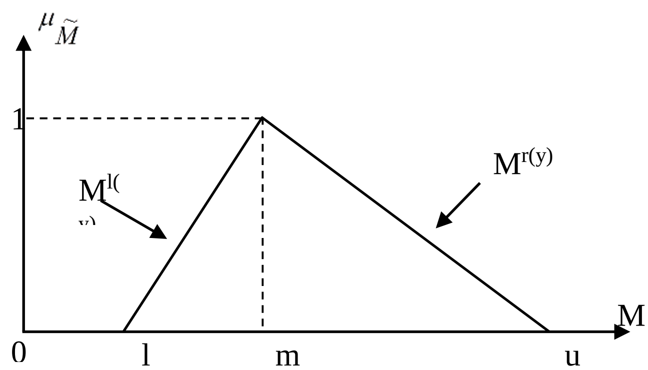

Figure 2. A triangular fuzzy number [7].

Fuzzy numbers are intuitively easy to use in expressing the decision maker’s qualitative assessments. A fuzzy number can always be given by its corresponding left and right representation of each degree of membership [11],

$$\tilde{M} = (M^{l(y)}, M^{r(y)}) = (l+(m-l)y, u+(m-u)y), \ y \ \varepsilon \ [0,1]. \quad (2)$$

Where l(y) and r(y) denote the left side representation and the right side representation of a fuzzy number, respectively. Kahraman et al. [41] have used the algebraic operations with fuzzy numbers.

3.3. Why Fuzzy-AHP instead of Classical AHP

Although AHP has been extensively used in solving the multi-criterion decision-making problems, it is problematic as it uses a scale of one to nine, which cannot handle uncertainty decisions in comparison of the attributes. During AHP implementation, all comparisons may not include a certainty, therefore, more than nine-point scale becomes necessary to describe the uncertainty. In this condition, to decide the priority of one decision variable over other, linguistic variables and triangular fuzzy numbers can be used. Synthetic extent analysis method is used to decide the final priority weights based on triangular fuzzy numbers and so called as Fuzzy Extended AHP (FEAHP) [6].

The FEAHP uses qualitative and quantitative data in the multi-attribute decision-making problems to handle the fuzziness in the decision process efficiently. In this approach, a nine-point scale of traditional AHP is replaced by triangular fuzzy numbers and then the extent analysis method is used to calculate the synthetic extent value of the pairwise comparison. After, the weight vectors are set and the normalized weight vectors are determined; the final priority weights for all the alternatives are computed using the different weights of criteria and attributes. As a result, the alternative with the highest weight is selected as the best [7].

3.4. Extent Analysis on Fuzzy AHP Method

In traditional AHP, a fundamental scale of 1 to 9 is used to decide the priority of one decision variable over another, whereas fuzzy AHP uses fuzzy numbers or linguistic variables [42]. In practice, decision makers highly prefer triangular or trapezoidal fuzzy numbers. As fuzzy numbers are used in fuzzy AHP, the solution methods are different from traditional AHP in fuzzy AHP applications [5]. The most common method used in the solution of fuzzy AHP applications is the extent analysis method proposed by Chang [24, 43]. The extent analysis method is applied to consider the extent of an object to be satisfied for the goal, that is, satisfied extent. In the method, the “extent” is quantified by using a fuzzy number. Based on the fuzzy values for the extent analysis of each object, a fuzzy synthetic degree value can be obtained, which is defined as follows.

In a product category selection problem, let $X = \{x_1, x_2, \ldots\ldots x_n\}$ represent the elements of the alternatives as an object set and let $U = \{u_1, u_2, \ldots\ldots u_m\}$ represent the elements of the supplier selection criteria as a goal set. According to the method of Chang’s extent analysis [16], each object is taken and extent analysis for each goal, g_i, is performed respectively. Therefore, m extent analysis values for each object can be obtained with the following signs:

$$M_{gi}^{1}, M_{gi}^{2}, \ldots M_{gi}^{m} \quad i=1,2, \ldots.n \tag{3}$$

Where all the M_{gi}^{j}, (j= 1, 2,…, m) are TFNs.

The steps of Chang’s extent analysis [11] can be given as in the following:

Step 1: The value of fuzzy synthetic extent with respect to its object is defined as

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} . \tag{4}$$

To obtain $\sum_{gi}^{j} M_{gi}^{j}$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right), \tag{5}$$

and to obtain $[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}]^{-1}$, perform the fuzzy addition operation of M_{gi}^{j} (j=1,2,…,m) values such that

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = (\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i), \quad (6)$$

and then compute the inverse of the vector in Eq. (6) such that

$$[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}]^{-1} = (\frac{1}{\sum_{i=1}^{n} u_i} \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}). \quad (7)$$

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as:

$$V(M_2 \geq M_1) = \sup [\min (\mu_{M1}(X), \mu_{M2}(y))], \quad (8)$$

and this can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = \text{highest}(M_1 \cap M_2) = \mu_{M2}(d) \quad (9)$$

$$= \begin{cases} 1, & \text{if } m_2 \geq m_1, \\ 0, & \text{if } l_1 \geq u_2, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{Otherwise} \end{cases}$$

where d is the ordinate of the highest intersection point D between μ_{M1} and μ_{M2}. In figure 3, the intersection between M_1 and M_2 can be seen.

To compare M_1 and M_2, we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

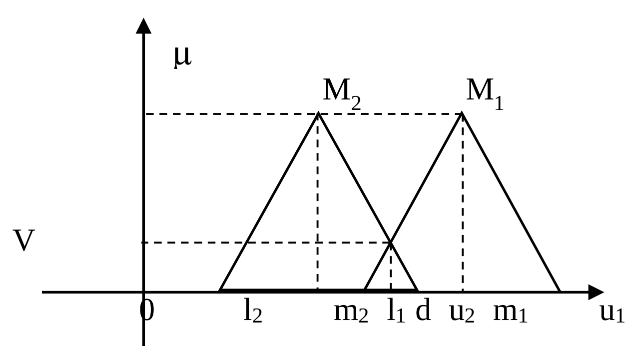

Figure 3. The interaction between M1 and M2.

Step 3: The degree of possibility for a convex fuzzy number to be larger than k convex fuzzy numbers M_i (i = 1,2,…,k) can be defined by

$$V(M \geq M_1, M_2, \ldots, M_k) = V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and} \ldots \text{and } (M \geq M_k)] = \min V(M \geq M_i), \; i = 1, 2, 3, \ldots, k. \quad (11)$$

Assume that

$$d'(A_i) = \min V(S_i \geq S_k). \quad (12)$$

For k = 1, 2,……, n; k ≠ i. Then the weight vector is given by μ

$$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T, \quad (13)$$

where A_i (i = 1, 2,…., n) are n elements.

Step 4: Via normalization, the normalized weight vectors are

$$W = (d(A_1), d(A_2), \ldots, d(A_n))^T, \quad (14)$$

where W is a non-fuzzy number. That gives the priority weights of one alternative over another.

4. A Case Study on Finding Best Apparel Items

In this product prioritization problem, the relative importance of different decision criteria involves a high degree of subjective judgment and individual preferences. The linguistic assessment of human feelings and judgments are vague and it is not reasonable to represent them in terms of precise numbers. It feels more confident to give interval judgments. Hence, for taking the priority of one decision variable over another, triangular fuzzy numbers are used. The triangular fuzzy numbers are determined from reviewing literature. Thereafter, synthetic extent analysis method is used to decide the final priority weights based on triangular fuzzy numbers and so-called as fuzzy extended AHP method. In the following sections, the main steps of the method have been explained thoroughly.

First Step: Defines the main attributes and alternatives for product category selection to design the fuzzy analytic hierarchy process tree structure. First, the overall objective of the product category prioritization problem has been identified which was ‘‘prioritization of the best product category for opening a garment factory’’. In the garments sector, a lot of criteria should be taken into account because the competition is really high. All of the possible important criteria, which could affect the supply of the critical part, have been discussed with an expert in the production planning department. In addition, other product category selection studies in the literature were reviewed with the expert. By combining the attributes that have been determined by the expert and the attributes that have been used in the literature, the main attributes and the alternatives in the study are determined. Four main attributes and five alternatives have been identified. The main determined attributes are Profitability, Initial investment, Raw material availability, Buyer demand. The alternatives attributes are Shirts, Trousers, Jackets, T-shirts and Sweaters.

4.1. Criteria

4.1.1. Profitability Criteria

Profitability of any product that should be considered before selecting product category, is one of the most important criteria counting on which investor decides to invest. If the investor feels the lower chance of profitability on a product, they will not be willing to pay on it.

4.1.2. Initial Investment Criteria

It is one of the key criteria that decision maker must consider before buying or developing something. Sometimes it can be a factor for decision maker of not going with any new scheme. It may be buyer has no ability to afford or develop it or somehow buyer has realized that this scheme is not such worthy, they are going to pay.

4.1.3. Raw Material Availability Criteria

Raw material is the primary substance which is used as an input to a production process for subsequent modification and finally modified into a finished good. Most of the times, raw materials in a garment factory are natural resources, such as cotton, oil, rubber. However, whatever raw materials are used, if there are a shortage of raw materials, it can harm greatly to the company. It may interrupt in the production of the factory. So raw material availability is highly needed.

4.1.4. Buyer Demand Criteria

When even a small business is started, it is usual to think about the necessity of their product to the customers. If everything is okay but the firm is not getting the expected response or orders. That means demand for that product has very lower value. At that case, running the firm becomes impossible. So product demand to the customer is a crucial criterion for selecting a category of products for opening a garment factory.

4.2. Alternatives

In this research, five alternatives are considered: Shirts, Trousers, Jackets, T-shirts and Sweaters. These are used to determine apparel item for a new factory from one’s standpoint in order to sustain global competitive business market. After determining the main attributes and alternatives, the hierarchy of the product category prioritization problem is structured. Figure 4 shows the structuring of the product category selection problem hierarchy of four levels. The top level of the hierarchy represents the ultimate goal of the problem, which is prioritization of a product category. The second level of the hierarchy is grouped into four categories, which are profitability attribute, initial investment attribute, raw material availability and buyer demand attribute. The bottom level of the hierarchy represents the five alternative product category. They are shirts, trousers, jackets, t-shirts and sweaters.

Second Step: Calculates the weights of the main attributes and alternatives. After the construction of the hierarchy, the different priority weights of each main attribute and alternative are calculated using the fuzzy AHP method. The questionnaire help to achieve the comparison of the importance of one main attribute and alternative over another.

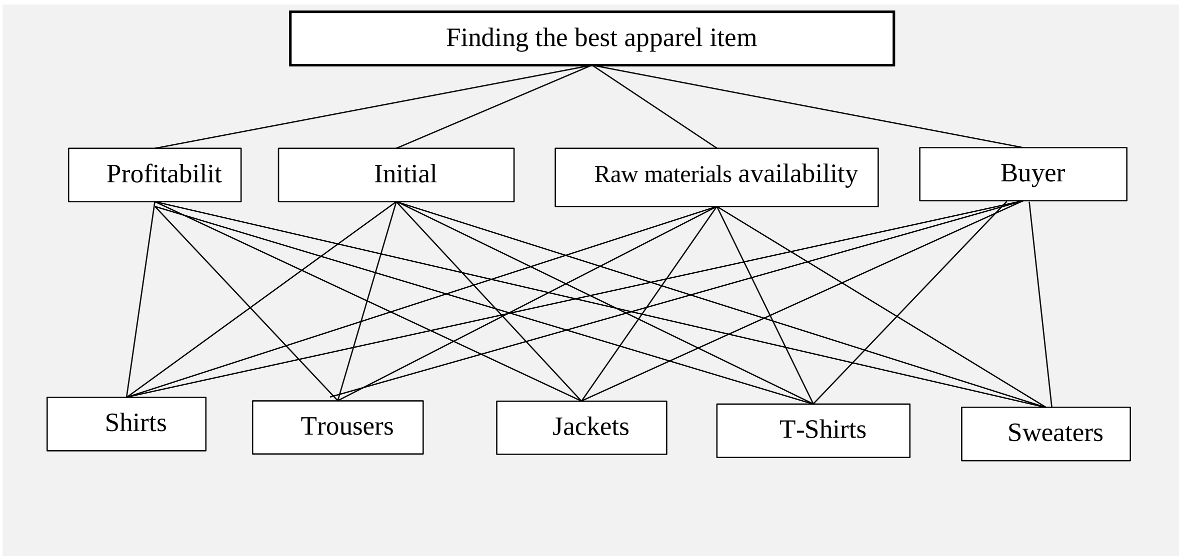

Figure 4. MCDM of products selection problem.

The questionnaires facilitate answering of pairwise comparison questions. Therefore, available research and the experience of the expert decide the preference of one measure over another [7]. First, the expert compares the main attributes with respect to the main goal. Then the expert compares the alternatives with respect to each main attributes. The expert uses the linguistic variables to make the pairwise comparisons. After that, the linguistic variables are converted to triangular fuzzy numbers. Table 3 shows the linguistic variables and their corresponding triangular fuzzy numbers. Owing to the limited space, the pairwise comparison matrix of main attributes with respect to the goal will be shown here. After forming the pairwise comparison matrices, the consistency of the pairwise judgment of each comparison matrix is checked using the calculation method of consistency index and consistency ratios in crisp AHP.

Each triangular fuzzy number, M = (l, m, u) in the pairwise comparison matrix is converted to a crisp number using M Crisp (l+4m+u)/6. After converting the fuzzy comparison matrices into crisp matrices, the consistency of each matrix is checked by the method in crisp AHP [44]. For this, first, multiplying together the entries in each row of the matrix and then taking the n^{th} root of that product. The n^{th} are summed and that sum is used to normalize the Eigen value. The next stage is to calculate λ_{max}, multiply total value of each column to Eigen value. The consistency index for a matrix is calculated from (λ_{max} - n)/ (n-1). Some randomly generated consistency index (R.I) values are shown in Table 4. Acceptability of alternative or attribute is measured in terms of Consistency Ratio (CR), $CR=\frac{CI}{RI}$. After calculation, the consistency ratio of each comparison matrix is found to be under 0.10. Therefore, we can conclude that the consistency of the pairwise judgments in all matrices are acceptable.

Table 3. The linguistic variables and their corresponding fuzzy numbers.

Linguistic scale	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Equally preferred	(1, 1, 1)	(1, 1, 1)
Weakly preferred	(2/3,1,3/2)	(3/2, 1, 2/3)
Fairly strongly preferred	(3/2,2,5/2)	(2/5,1/2,2/3)
Very strongly preferred	(5/2,3,7/2)	(2/7,1/3,2/5)
Absolutely preferred	(7/2,4,9/2)	(2/9,1/4,2/7)

Table 4. Consistency Index, *RI*, of random matrices.

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 5 shows evaluation of fuzzy evaluation matrix with respect to the main attribute using the triangular matrix. Consistency Ratio (CR) must be checked before finding the priority weight of main attributes.

Table 5. The fuzzy evaluation matrix with respect to goal with triangular fuzzy numbers.

Goal/attributes	Profitability	Initial investment	Raw material availability	Buyer demand
Profitability	(1,1,1)	(3/2,2,5/2)	(2/3,1,3/2)	(1,1,1)
Initial investment	(2/5,1/2,2/3)	(1,1,1)	(2/3,1,3/2)	(2/3,1,3/2)
Raw material availability	(2/3,1,3/2)	(2/3,1,3/2)	(1,1,1)	(3/2,2,5/2)
Buyer demand	(1,1,1)	(2/3,1,3/2)	(2/5,1/2,2/3)	(1,1,1)

Table 5.1. Calculating Geometric mean, Eigen value using Crisp AHP method for Table 5.

Attributes	Profitability	Initial investment	Raw material availability	Buyer demand	Geometric mean	Eigen value
Profitability	1.0000	2.0000	1.0278	1.0000	1.0138	0.2714
Initial investment	0.5111	1.0000	1.0278	1.0278	0.8572	0.2295
Raw material availability	1.0278	1.0278	1.0000	2.0000	1.0124	0.2711
Buyer demand	1.0000	1.0278	0.5111	1.0000	0.8513	0.2280
Total	3.5389	5.0556	3.5667	5.0278	3.7347	

λ_{max} = (3.5389 * 0.2714) + (5.0556 * 0.2295) + (3.5667 * 0.2711) + (5.0278 * 0.2280)

= 4.2339, CI = $\frac{4.2339-4}{4-1}$ = 0.0780, RI = 0.90, CR= 0.0866 = 8.66%.

As CR < 10%, the level of inconsistency of comparison matrix is satisfactory.

In order to find the priority weights of the main attributes, first, the fuzzy synthetic extent values of the attributes are calculated by using Eq. (4). The different values of fuzzy synthetic extent of the four different main attributes are denoted by S_P, S_I, S_R, S_B.

S_P = (4.1667, 5, 6) $\otimes$ (1/21.3333, 1/17.0000, 1/13.8000) = (0.1953, 0.2941, 0.4348).
S_I = (2.7333, 3.5, 4.667) $\otimes$ (1/21.3333, 1/17.0000, 1/13.8000) = (0.1281, 0.2059, 0.3382).
S_R = (3.833, 5, 6.5) $\otimes$ (1/21.3333, 1/17.0000, 1/13.8000) = (0.1797, 0.2941, 0.4710).
S_B = (3.0667, 3.5, 4.1667) $\otimes$ (1/21.3333, 1/17.0000, 1/13.8000) = (0.1438, 0.2059, 0.3019).

The degree possibility of S_i over S_i ($i \neq j$) is determined by using equations (9) and (10).

V ($S_P \geq S_I$) = 1.000	V ($S_I \geq S_R$) = 0.6424	V ($S_R \geq S_B$) = 1.000	V ($S_B \geq S_P$) = 0.5472.
V ($S_P \geq S_R$) = 1.000	V($S_I \geq S_B$) = 1.000	V($S_R \geq S_P$) = 1.000	V ($S_B \geq S_I$) = 1.000.
V ($S_P \geq S_B$) = 1.000	V ($S_I \geq S_P$) = 0.6182	V ($S_R \geq S_I$) = 1.000	V ($S_B \geq S_R$) = 0.5808.

With the help of Eq. (12), the minimum degree of possibility is stated as below:

d' (P) = min (1.000, 1.000, 1.000) = 1.000.
d'(I) = min (0.6424, 1.000, 0.6182) = 0.6182.
d'(R) = min (1.000, 1.000, 1.000) = 1.000.
d'(B) = min (0.5472, 1.000, 0.5808) = 0.5472.
Weight vector, W' = (1, 0.6182, 1, 0.5472).

Therefore, the weight is given as W' = (1.000, 0.6182, 1.000, 0.5472). After normalization process, the weight vector of the main attributes, which are profitability, initial investment, raw material availability and buyer demand attribute is found to be W_G = (0.3159, 0.1953, 0.3159, 0.1729)^T. We can conclude that the most important attribute in the product selection process is profitability and raw material availability attribute, because it has the highest priority weight. Initial investment and buyer demand attribute is the next preferred attribute.

Third Step: Compares alternatives under each criterion separately. This is shown in Table (6-9). Inconsistency of TFN can be checked and the consistency ratio (CR) may be calculated.

Table 6. The fuzzy comparison matrix for the “profitability” criteria,

λ_{max} = 5.4048, CI= 0.1012, RI= 1.1200, CR= 9.04%.

Attributes	Shirts	Trousers	Jackets	T-Shirts	Sweaters	Defuzzified normalized weight	Percentage
Shirts	(1, 1, 1)	(2/3,1,3/2)	(2/5,1/2,2/3)	(2/3,1,3/2)	(3/2,2,5/2)	0.2022	20%
Trousers	(2/3,1,3/2)	(1,1,1)	(3/2,2,5/2)	(1,1,1)	(2/3,1,3/2)	0.2285	23%
Jackets	(3/2,2,5/2)	(2/5,1/2,2/3)	(1, 1, 1)	(2/7,1/3,2/5)	(2/3,1,3/2)	0.1421	14%
T-Shirts	(2/3,1,3/2)	(1,1,1)	(5/2,3,7/2)	(1, 1, 1)	(3/2,2,5/2)	0.3415	34%
Sweaters	(2/5,1/2,2/3)	(2/3,1,3/2)	(2/3,1,3/2)	(2/5,1/2,2/3)	(1, 1, 1)	0.0857	09%

Table 7. The fuzzy comparison matrix for the "initial investment" criteria, λ_{max} = 5.4144, CI= 0.1036, RI= 1.1200, CR= 9.25%.

Attributes	Shirts	Trousers	Jackets	T-Shirts	Sweaters	Defuzzified normalized weight	Percentage
Shirts	(1, 1, 1)	(1,1,1)	(3/2,2,5/2)	(3/2,2,5/2)	(2/3,1,3/2)	0.2971	30%
Trousers	(1,1,1)	(1,1,1)	(2/3,1,3/2)	(2/3,1,3/2)	(5/2,3,7/2)	0.2971	30%
Jackets	(2/5,1/2,2/3)	(2/3,1,3/2)	(1, 1, 1)	(2/5,1/2,2/3)	(1,1,1)	0.0783	08%
T-Shirts	(2/5,1/2,2/3)	(2/3,1,3/2)	(3/2,2,5/2)	(1, 1, 1)	(3/2,2,5/2)	0.2706	27%
Sweaters	(2/3,1,3/2)	(2/7,1/3,2/5)	(1,1,1)	(2/5,1/2,2/3)	(1, 1, 1)	0.0570	06%

Table 8. The fuzzy comparison matrix for the "raw material availability" criteria, λ_{max} = 5.3918, CI= 0.0980, RI= 1.1200, CR= 8.75%.

Attributes	Shirts	Trousers	Jackets	T-Shirts	Sweaters	Defuzzified normalized weight	Percentage
Shirts	(1, 1, 1)	(3/2,2,5/2)	(5/2,3,7/2)	(1,1,1)	(2/3,1,3/2)	0.3825	38%
Trousers	(2/5,1/2,2/3)	(1,1,1)	(3/2,2,5/2)	(2/5,1/2,2/3)	(3/2,2,5/2)	0.2349	23%
Jackets	(2/7,1/3,2/5)	(2/5,1/2,2/3)	(1, 1, 1)	(2/3,1,3/2)	(1,1,1)	0.0000	0%
T-Shirts	(1,1,1)	(3/2,2,5/2)	(2/3,1,3/2)	(1, 1, 1)	(5/2,3,7/2)	0.3825	38%
Sweaters	(2/3,1,3/2)	(2/5,1/2,2/3)	(1,1,1)	(2/7,1/3,2/5)	(1, 1, 1)	0.0000	0%

Table 9. The fuzzy comparison matrix for the “demand of buyers” criteria, λ_{max} = 5.3855, CI= 0.0964, RI= 1.1200, CR= 8.60%.

Attributes	Shirts	Trousers	Jackets	T-Shirts	Sweaters	Defuzzified normalized weight	Percentage
Shirts	(1, 1, 1)	(2/5,1/2,2/3)	(2/5,1/2,2/3)	(3/2,2,5/2)	(2/3,1,3/2)	0.1559	16%
Trousers	(3/2,2,5/2)	(1,1,1)	(2/5,1/2,2/3)	(2/3,1,3/2)	(2/7,1/3,2/5)	0.1402	14%
Jackets	(3/2,2,5/2)	(3/2,2,5/2)	(1, 1, 1)	(3/2,2,5/2)	(1,1,1)	0.3361	34%
T-Shirts	(2/5,1/2,2/3)	(2/3,1,3/2)	(2/5,1/2,2/3)	(1, 1, 1)	(2/3,1,3/2)	0.0852	09%
Sweaters	(2/3,1,3/2)	(5/2,3,7/2)	(1,1,1)	(2/3,1,3/2)	(1, 1, 1)	0.2826	28%

As mentioned before, these matrices are used to estimate weights, in this case, the weights of each alternative under each criterion separately. The results are given in Table 10.

Table 10. Weights of each alternative to each criterion.

Attributes	Profitability	Initial investment	Raw material availability	Demand of buyers
Shirts	0.2022	0.2971	0.3825	0.1559
Trouser	0.2285	0.2971	0.2349	0.1402
Jackets	0.1421	0.0783	0	0.3361
T-shirt	0.3415	0.2706	0.3825	0.0852
Sweater	0.0857	0.057	0	0.2826

Final Step: a final score is obtained for each candidate by adding the weights per candidate and multiplying the weights of the corresponding criteria. Table 11 shows these scores.

Table 11. Final evaluation of the Fuzzy-AHP approaches.

Products/weights	Profitability	Initial investment	Raw material availability	Demand of buyers	Composite weights	Percentage of composite weights	Final ranking
	0.3159	0.1953	0.3159	0.1729			
Shirts	0.2022	0.2971	0.3825	0.1559	0.2696	27%	2
Trouser	0.2285	0.2971	0.2349	0.1402	0.2286	23%	3
Jackets	0.1421	0.0783	0.0000	0.3361	0.1182	12%	4
T-shirt	0.3415	0.2706	0.3825	0.0852	0.2962	29%	1
Sweater	0.0857	0.057	0.0000	0.2826	0.0870	09%	5

5. Results and Discussions

Table 11 shows the ranking of five basic apparel items depending on the values of composite weights. T-shirt item is determined as the most profitable apparel item to invest in Bangladesh.

In the ranking, shirts, trousers, jackets, and sweaters items are determined second, third, fourth and fifth, respectively. It should be noted that any changes in any criteria might change the result. For instance, in this case, T-shirt is selected as best apparel item to invest considering lower capital investment capability, but if the investor has no problem with raw capital then the optimum result may switch to the other apparel items. The application of the proposed methodology to the case study of finding out the best apparel item led to the following conclusion. The method was capable to provide decision support to the investors and entrepreneurs for starting-up with new garments factory. The method provided different results because different investors stand on different level with respect to resources.

6. Conclusions and Future Works

The use of systematic approach to reach the best decision was preferred in any business sectors. There was a tendency among young generation in Bangladesh to move out from routine job and do something their own. Due to the huge opportunities, having a little work experiences in garment, they look for business in this sector. The success in this sector with new garment factory is very much challenging to sustain in competitive market. Since the factories of different apparel items require different types of skills, knowledge and resources, so the decision of where to exactly invest was the key factor. A good decision was much crucial and important factor to success. The main goal of this paper was to provide a decision support to the investor by selecting best apparel item to start-up business in garments sector. In this paper, T-shirt was obtained as a best item but result might be changed with different investor as different investors stand on different level with respect to resources. However, the result indicated the proposed model was quite capable to solve decision problems associated with product selection in starting up business. The proposed method was quite general and allowed investors to analysis the decision problem considering many aspects and different points of views. The method was also capable to solve any types of real life decision-making problem with only minor modifications. Many others multi-criterion decision-making approaches, such as VIKOR, GRA, ANP, and TOPSIS can also be used to obtain this solution.

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