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Risk Prioritization and Management in Gas Stations by using Fuzzy AHP and IPA Analysis

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Gasoline industry is the main pillar of Pakistan's economy and is of immense importance. This industry is confronted by diverse risks which significantly affect its performance resulting in decreased economic contribution. On the other side, published literature merely analyzes this industry and suggests directions to improve it. Thus, this study is a kickoff step in this regard, and its purpose is to study the relationship between risk factors, importance, and performance of gasoline industry, which is based on questionnaire data collected from three districts, viz., Gujranwala, Gujrat and Sialkot of Punjab, Pakistan. In total, 159 completed questionnaires were collected having consistency ratio (CR) less than 0.1. Acquired stats were investigated using the latest techniques of multi-criteria decision making routines, viz., fuzzy analytic hierarchy process (Fuzzy AHP) and importance performance analysis (IPA) software Expert Choice 2000. Among the five main risk types faced by gasoline industry, transportation / tanker unloading (importance, 0.467: rank, 1) was the most, whereas, the least significant factor was miscellaneous category (importance, 0.049: rank, 5). Moreover, the most significant factor which showed high importance with high performance was driving carelessness / accidents (importance, 0.278; performance, 3.32), high importance with low performance was uncontrolled vapor released (importance, 0.087; performance, 2.53), low importance with low performance was fire / explosion (importance, 0.021; performance, 2.66) and low importance with high performance was overfill / crossover (importance, 0.027; performance, 4.11). Thus, this work identifies, prioritizes and highlights the areas where improvement is needed to encounter risk and increase quality function development of gas stations.

Keywords: Analytic hierarchy process, Gasoline, Importance performance analysis, Quality function development, Risk administration, Risk ranking

Introduction

In this era, the process of urbanization is at full swing. Obviously, this remarkable development is charming, however, on the other side it has potential dangers to human society. Among various threats posed by urbanization, accidents associated with gas stations are quite prominent. Gas station calamities have resulted in enormous socioeconomic losses around the world. For instance, it is reported that in Korea, 1992 to 2003, 41 tragic incidents have occurred. Among, these happenings, 25 accidents were disastrous explosions or fire cases. These accidents caused huge economic losses as only one incident allegedly resulted into a damage worth 13 million USD.[1] Likewise, in Tehran, 22817 cases of fire have been reported from 2002 to 2006, among which significant number of cases, i.e., 480 occurred at hazardous place such as gas stations.[2]

Unfortunately, Pakistan has significant number of accidents associated with gas stations. Only in one year of 2008, 1203 various kinds of accidents are reported. It is found that there are several hazard contributing factors such as transportation, carelessness, electrical fault, fire, housekeeping, slips trips and falls, medical treatments and some other cases resulting these events.[3] In order to manage such kinds of risks, it is pivotal to establish comprehensive system of risk assessment. This is the only compulsory first step which can lay the foundation to systematically control such catastrophes. For managing hazardous materials several stages have been proposed to study level of risk.[4] In this regard, first stage is to access neighboring place in terms of risk.[5] Various published studies elaborate this stage. Such as, in 1996, condition and state of tanks containing hazardous substances were described by British Ministry of Defense.[2] For managing fire, its risk assessment by analyzing the factors such as fire, fire alert, rise of temperature during fire and use of

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fire extinguisher are well documents in published literature.[6] Importance of assessing risk at places having large amount of stored fuel is stressed by several studies. One study found that fire extinguisher, electric system, transmission lines, fuel status and station structures are key factors to be accessed for better management of these places.[7]

In this regard, nowadays several statistical routines are employed to access risk among which two methods are very popular and reliable, viz., Fuzzy Analytical Hierarchy Process (Fuzzy AHP) and Importance Performance Analysis (IPA). These two statistical tools have many advantages over the others. Such as, fuzzy theory of AHP assists to take clearer, accurate, and distinct decisions based on objective evaluation of problems.[8] This method empowers to make flawless judgements in ambiguous situations or unclear linguistic expressions.[9] This theory complements subjectivity to crack encountered snags. Fuzzy AHP is an excellent statistical multi-attribute decision making routine which has a capability to lessen bias.[10] The calculations of fuzzy AHP are based on scales rather on some measurements. Thus, fuzzy AHP can be used in uncertainty or modelling risk situations, the situations which lack measurements.[11] Likewise, IPA plots importance against performance, i.e., two way grid into four quadrats. Thus, various attributes represented by these quadrats based on calculated scores help entrepreneurs to prioritize effective performance.[12,13] Various studies indicate that the use of IPA controls excess resource consumption by facilitating entrepreneurs to have deep insight into factors which needs performance improvement.[14] Based on these advantages, plethora of literature signifies the use of IPA tool in representative studies in various fields. For instance, in one study, IPA method was modified to improve business strategic management. Such an upgraded version could assist managers to point out and select better business management strategies.[15] Likewise, some studies also used IPA routine to find out main areas of operation in the context of managerial opinions.[16] Similarly, IPA matrix is also applied to unveil relationship between risk perception and the performance.[17] Thus, based on above stated advantages, prominence and popularity in industrial risk management studies this study employs fuzzy AHP and IPA statistical methods.

Objectives of this study are multifaceted. First, it strives to recognize as well as hierarchically organize risk factors faced by gasoline industry in Pakistan based upon published literature and data collected through this study. Second, it endeavors to prioritize risk factors by giving weights to each perceived risk type with the help of fuzzy AHP and IPA. Third, it establishes a relationship between risk factors importance and performance thus innovatively helps entrepreneurs for managing gasoline industry. It is envisaged that through this study entrepreneurs will be able to find areas where better risk management practices are needed to further strengthen this industry.

Materials and Methods

Data Acquisition

In order to fetch statistical data for this study, questionnaire survey was conducted from 3 October to 26 December, 2020. Main objective of this study was to explore diverse types of risks faced by gasoline industry in Pakistan and give these risks priority ranks for better and effective management of this sector as aforementioned. For achieving this objective, industry specialists were contacted for their expert opinion located in three districts of Pakistan, viz., Gujranwala, Gujrat and Sialkot. In this regard, face-to-face interviews, based on the purposely designed questionnaire, were taken to ensure reliability and accuracy of data. In total, 159 completed questionnaires were collected having consistency ratio (CR) less than 0.1. Acquired stats were investigated using the fuzzy AHP and IPA software Expert Choice 2000. This software focuses on the data fetched from experts of a field and may use less than 10 questionnaires. Therefore, most of the published literature using this software employ around 50 questionnaires. However, in this situation lower numbers of pair wise comparison sets were formed. In order to increase reliability and fully represent appropriate population we have used 159 completed questionnaires for analysis. CR was estimated from fuzzy AHP results. CR less than 0.1 indicates a considerably high logical consistency among the expert population evaluated and was well-thought-out for the drawing of reliable results.[10,18] It is necessary to mention that data validation was of prime importance in this study. It was done at the three steps. First, survey questionnaire was reviewed by a Professor in this field so that we do not skip any important question related to any main risk or sub-risk. Second, during data collection, survey participants were randomly selected based on their professional knowledge of gasoline industry by considering various factors such as working experience, qualification etc. Thus, the survey participant's adequately represented appropriate population. Third, we tried to fetch a sufficient data and calculated CR value. Questionnaires having only acceptable values of CR were considered for further analysis.

Data Analysis

Acquired results were ranked and given importance rating depending upon gathered data by using fuzzy AHP and IPA methods. Whole process of research from start to end is thoroughly depicted in Fig. 1. Collected data was regarded as matrix and was statistically normalized through fuzzy AHP. In this process, matrix normalization, small data value was achieved to get maximum calculation output. This was done by aligning diverse attribute values. Following equation demonstrates this procedure numerically:

$$r_{ii} = \frac{x_{ij}}{max_i\, x_{ij}};\ j = 1, 2, 3, \ldots, m;\ i = 1, 2, 3, \ldots, n \qquad \ldots (1)$$

where, r_{ii}, max_i and x_{ij} denote matrix (normalized), each column maximum value and matrix (decision), in that order. The normalization procedure is primarily based on special type of normalization equation called "simple additive weight".[19] Matrix normalization is a basic step for exploring correlation between various criteria. This was done by using fuzzy analytic hierarchy process theory (fuzzy AHP). Fuzzy AHP uses a ratio scale formed on pairs of criteria for comparison.[20] This method has a quality to treat issues related to decision making problems, qualitative as well as quantitative.[21] In fuzzy AHP a specific scale is used to compare criteria. This scale was suggested by Saaty and ranges between 1 and 9.

Considerable amount of published literature indicates that AHP method is combined with some other method. Fuzzy AHP is an excellent example for this union of methods. This method is particularly important and specifically built for handling fuzzy decisions.[22] Fuzzy method uses a distinct technique in which a set of 3 numbers is used (triangular fuzzy number or TFN). In fuzzy graphs, values oscillates between 0 and 1.[23] This method is actually based upon

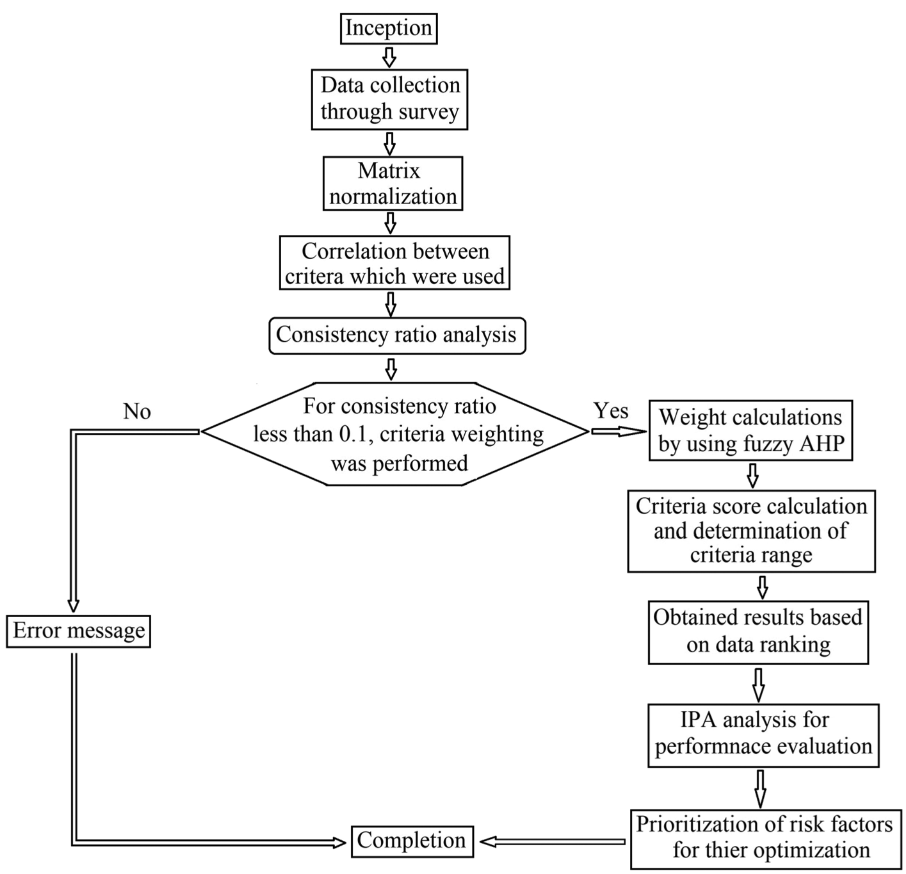

Fig. 1 — Flowchart of research

two sets of fuzzy numbers, i.e., first group of number having actual values and second group having inverse of first group. This simply means that changing x to 1/x along with reversing number orders. Actually, through fuzzy AHP humans can make decisions more conveniently and precisely by considering perceptions about inconsistencies which may occur due to decisions. Fuzzy AHP helps to identify whether particular decision will result into inconsistency or not. Fuzzy AHP predicts this by consistency index (*CI*) give as follows:

$$CI = \frac{t-n}{n-1} \quad \dots (2)$$

In the ordered matrix containing numbers n, the most considerable normalization value is indicated by *t* as shown in above equation. If CI = 0, then matrix is assumed to be consistent. This step is very important as it determines matrix comparison in a pairwise fashion. Moreover, limits of inconsistency, consistency ratio (CR) have been described by Saaty represented in the following equation:

$$CR = \frac{CI}{IR} \quad \dots (3)$$

CR compares CI and random index value (IR). The upper limit of CR is 0.1. It means that either estimated value of CR is equal or lower than 0.1. Thus, decision making inconsistencies can be recognized whenever CR value is equal or lower than 0.1. Otherwise, for other values data needs reprocessing. Fuzzy AHP estimations depend upon obtained CR values by calculating weight of the criterion used. This procedure entails two key steps: First, transforming criterion interrelationship into TFN; Second, estimation of level of probability. Criterion relation matrix is computed by putting value in triangle with respect to the value of criterion interrelationship. If the obtained criterion matrix value is above 1, then TFN number is also used in the first group along with the second group. Afterwards, this procedure added TFN numbers were added up between criteria. Furthermore, for each column value calculation was divided by number of relations.

Calculation of probability level yielded weight value. In order to get weight value, principal of comparison was used which used vector value estimation as shown in the following equation:

$$V(M2 \geq M1) = \begin{cases} 1 & , if\ m_2 \geq m_1 \\ 0 & , If\ \ l_1 \geq u_2 \\ \frac{(l_1-u_2)}{(m_2-u_2)-(m_1-l_1)} & , other \end{cases} \quad \dots (4)$$

Estimations by using each column and row data produced possible degrees as shown in above equation. The last step in this process was to determine range and ranking of data. For this mean squared error value, quadratic error value, was determined to get normalized criterion weight and is represented by equation as follows:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(f_i - y_i)^2 \quad \dots (5)$$

Besides, this study also employed IPA analysis. In this analysis, 2-dimentional matrix, i.e., importance on x-axis and performance on y-axis are used. Thus, these two matrix interplay in four ways. First part of obtained IPA graph is usually designated as Quadrant I and indicates risk factors having high importance along with high performance. Otherwise, second part of IPA graph represented as Quadrant II signifies high importance but low performance. This section is very important as in order to increase overall sector's performance risk management should concentrate on these risk factors. Ignorance towards the management of these risk factors may result in sector's low performance. On the other hand, Quadrant III indicates risk factor both in low importance as well as performance. Thus, these risk factors are treated as of low priority. The last Quadrant IV connote low importance but high performance which suggest to shift resources from this sector to others.[24]

Results and Discussion

This preliminary study endeavors to prioritize risk factors faced by gas stations for comprehensive management of gasoline industry. Data sampling methods used for this study are standard one and have already been employed in several latest risk management studies for gas stations.[25,26] Besides, numerous published studies argue that the opinion of workers in understanding and managing hazardous places is indispensable.[27–29] Thus, workers risk perception is of central importance for making strategies regarding the management of hazardous places.[28] Considering this background, we have collected data from participants directly concerned with gasoline industry to increase the reliability of this study. Various types of survey participants contributed in this study. Their particulars are presented in Table 1. In the process of AHP decision-making, due to the great subjectivity of expert scoring, in order to reduce the impact of this subjectivity on the decision-making results and improve the accuracy of conclusions, the number of experts in general AHP should be 10 or more. On the other side, the sample size is adequate for the sample size reflect the appropriate population and the duration on all sample's job are more than 5 years. For the validation of data, the numbers of survey participants in different groups are decided by the methods of its stratified ratios and non-proportional distribution. The ratio of different categories of survey participants is very important. But for the ratio of managers/senior workers is too small, its estimated number is less than 10, in order to fully reflect the characteristics of managers/senior workers, so its number have been artificially increased to 12.

Moreover, based upon the collected data, it was found that gasoline industry is confronting five main types of risks, viz., transportation / tanker unloading, storage of fuel on site, dispensing of fuel, repair, maintenance or modification and miscellaneous risks. These main types of risks along with their sub-types are presented in Fig. 2. Similar types of risks have also been reported in the literature.[25]

The relative importance and priority ranking of main risk factors are highlighted in Fig. 3. This study found that 'Transportation / Tanker Unloading (TU)' (Importance, 0.467: Rank, 1) was the most significant risk factor. Similar results have also been reported by other studies. For instance, Ahmed *et al*. (2011) have reported transportation risk as a main hazard faced by gasoline industry due to which 255 tragic events occurred during 2008.[(30)] Second most significant risk factor described by this study was 'Dispensing of Fuel' (Importance, 0.261: Rank, 2). In Pakistan, dispensing of fuel is mostly done by low-educated and poorly trained people which results in bad events. During travelling, vehicles stop at gas stations to re-fill while conductors, drivers and sometimes passenger use cigarettes during this process. The vapors released during dispensing of fuel catch fire and result in blasts.[31]

Third most significant risk factor was 'Storage of Fuel on Site (SFS)' (Importance, 0.144: Rank, 3). This risk factor, also known as housekeeping, is very important to manage in developing a safe work place. It represents maintenance and cleaning of all the equipment involved with gas stations.[32] It has been reported that in Pakistan 55 events have occurred during 2008 because of this hazard.[30] The remaining

Table 1 — Frequency analysis of survey participants

	Categories	Frequency	Percent
Position	Managers / Senior Workers	12	7.5
	Associate Workers	51	32.1
	General Workers	96	60.4
Qualification	Ph.D.	15	9.4
	Masters	60	37.7
	Bachelor / Others	84	52.8
Duration on job	Between 5 to 10 years	51	32.1
	More than 10 years	108	67.9
Area	Gujranwala District	96	60.4
	Gujarat District	48	30.2
	Sialkot District	15	9.4
	Total	159	100.0

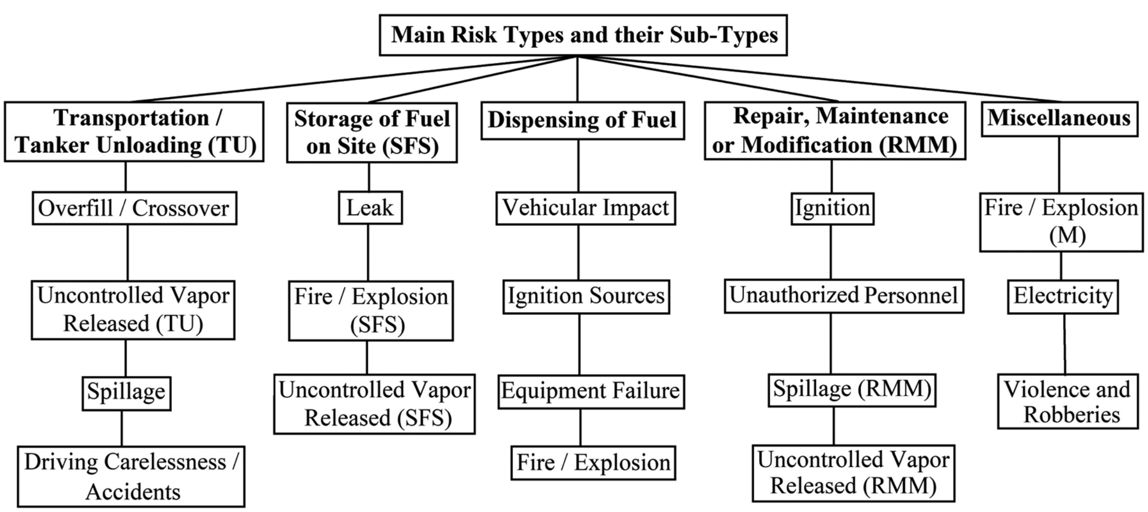

Fig. 2 — Diverse types of risks faced by gasoline industry in Pakistan (Research Model).

two risk factors are 'Repair, Maintenance or Modification (RMM)' (Importance, 0.079: Rank, 4), and 'Miscellaneous' (Importance, 0.049: Rank, 5). Both of these risk factors have very low importance. Since, CR was less than 0.1, thus consistency of the analysis is confirmed.

Furthermore, we also calculated relative importance and priority ranking for risk sub-factors (Fig. 4). In the risk category of Transportation / Tanker Unloading (TU), 'Driving carelessness / Accidents' showed the highest importance (0.596). There are 244 recorded incidents in Pakistan during 2008 because of this risk sub-factor. Such accidents usually happen as heavy vehicles collide with each other mainly because of lack of attention paid by drivers.[30] Lack of proper training and absence of driving license are found to be responsible for these miserable incidents.[33] Moreover, poor vehicle condition, alcoholism and absence of seat belt further add to this risk category.[34]

Among various sub-factors of main risk type 'Storage of Fuel on Site (SFS)', 'Leak' showed the highest importance (0.450). In order to control leak, mostly a special type of valve is used which controls excess flow of gas. However, malfunction of this value may result into accidents. In Pakistan, because of this risk several accidents have been reported killing of dozens of people.[3] Several studies have shown that leak hazard is a true havoc for workers working at gas stations as they handle many liters of

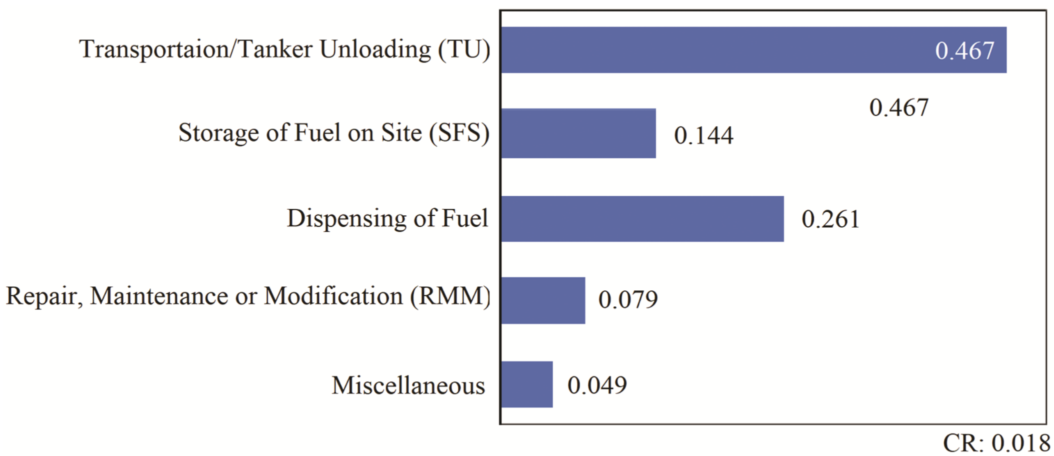

Fig. 3 — Estimated fuzzy AHP results for relative importance and priority ranking of main risk factors.

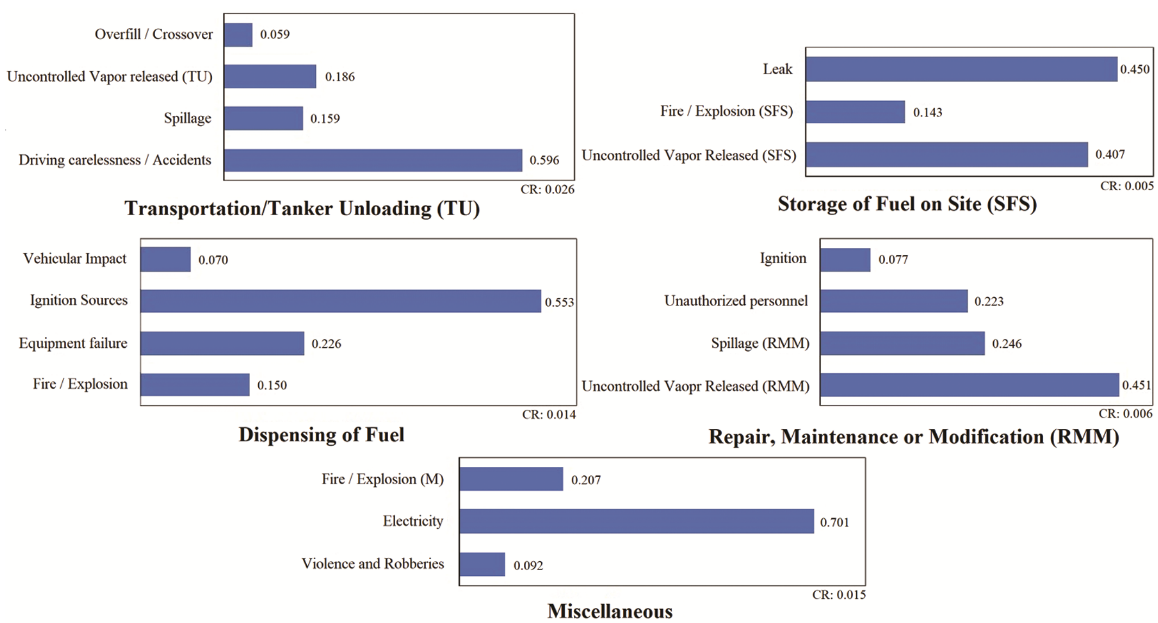

Fig. 4 — Estimated fuzzy AHP results for relative importance and priority ranking of risk sub-factors

fuel on daily basis. Exposure to such kind of environment pushes workers to encounter serious health issues.[35,36] Followed by 'Uncontrolled Vapor Released (SFS)' (0.407), and 'Fire / Explosion (SFS)' (0.143). Since, CR was less than 0.1, thus consistency of the analysis was confirmed. On the other hand, amongst diverse Dispensing of Fuel sub-factors, 'Ignition Sources' revealed the highest importance (0.553) followed by 'Equipment failure' (0.226), 'Fire / Explosion' (0.150) and 'Vehicular Impact' (0.070). Since, CR was less than 0.1, thus consistency of the analysis was confirmed.

Within the risk type of 'Repair, Maintenance or Modification (RMM)', 'Uncontrolled Vapor Released (RMM)' displayed the highest importance (0.451) followed by 'Spillage (RMM)' (0.249), 'Unauthorized personnel' (0.223), and 'Ignition' (0.077). Since, CR was less than 0.1, thus consistency of the analysis was confirmed. Amid the risk type 'Miscellaneous', 'Electricity' exhibited the highest importance (0.701). It is reported that 97 incidents have occurred in 2008 because of electric faults.[30] However, it was observed during this study that still there are no effective measures to encounter this risk sub-type. Second risk sub-type is 'Fire / Explosion (M)' (0.207). Obviously, fuels are flammable and have immense potential to catch fire at gas stations. Thus, assessment to fire hazard is the back bone of fire management.[37] In Pakistan, 17 fire events occurred during 2008.[(30)] Whereas, third risk sub-type is 'Violence and Robberies' (0.092). Published literature indicates that this risk sub-type should be an integral part of management plan for gas station safety measure.[38] However, there are meager published research that describes such kinds of risk sub-factors in Pakistan. Since, CR was less than 0.1, thus consistency of the analysis was confirmed (Table 2).

Overall importance and priority ranking of all risk sub-factors was also estimated. The most important risk sub-factor was 'Driving carelessness / Accidents' (Importance, 0.278; Rank, 1) followed by 'Ignition Sources' (Importance, 0.145; Rank, 2), 'Uncontrolled Vapor Released (TU)' (Importance, 0.087; Rank, 3), 'Spillage ' (Importance, 0.074; Rank, 4), 'Leak' (Importance, 0.065; Rank, 5), 'Equipment failure' (Importance, 0.059; Rank, 6), 'Uncontrolled Vapor Released (SFS)' (Importance, 0.059; 7), 'Fire / Explosion' (Importance, 0.039; Rank, 8), 'Uncontrolled Vapor Released (RMM)' (Importance, 0.036; Rank, 9), 'Electricity' (Importance, 0.034; Rank, 10), 'Overfill / Crossover' (Importance, 0.027; Rank, 11), 'Fire / Explosion (SFS)' (Importance, 0.021; Rank, 12), 'Spillage (RMM)' (Importance, 0.020; Rank, 13), 'Vehicular Impact' (Importance, 0.018; Rank, 14), 'Unauthorized personnel' (Importance, 0.018; Rank, 15), 'Fire / Explosion (M)' (Importance, 0.010; Rank, 16), 'Ignition' (Importance, 0.006; Rank, 17), and 'Violence and Robberies' (Importance, 0.005; Rank, 18).

In our study, factors that showed high importance with high performance were 'Driving carelessness / Accidents' (Importance, 0.278; Performance, 3.32) and 'Equipment failure' (Importance, 0.059; Performance, 3.85). On the other hand, factors that showed high importance with low performance were 'Uncontrolled Vapor Released (TU) (Importance, 0.087; Performance, 2.53), 'Spillage' (Importance, 0.074; Performance, 2.68), 'Leak' (Importance, 0.065; Performance, 2.92), 'Uncontrolled Vapor Released (SFS)' (Importance, 0.059; Performance, 2.21) and 'Ignition Sources' (Importance, 0.145; Performance, 2.13).

Factors that showed the low importance with low performance were 'Fire / Explosion (SFS)' (Importance, 0.021; Performance, 2.66), 'Fire / Explosion' (Importance, 0.039; Performance, 2.58), 'Ignition' (Importance, 0.006; Performance, 2.79), 'Spillage' (RMM) (Importance, 0.020; Performance, 2.64), 'Uncontrolled Vapor Released (RMM)'

Table 2 — Estimated fuzzy AHP results for relative importance and ranking of risk sub-factors

Sub-Factors	Importance	Ranking
Overfill / Crossover	0.027	11
Uncontrolled Vapor Released (TU)	0.087	3
Spillage	0.074	4
Driving carelessness / Accidents	0.278	1
Leak	0.065	5
Fire / Explosion (SFS)	0.021	12
Uncontrolled Vapor Released (SFS)	0.059	7
Vehicular Impact	0.018	14
Ignition Sources	0.145	2
Equipment failure	0.059	6
Fire / Explosion	0.039	8
Ignition	0.006	17
Unauthorized personnel	0.018	15
Spillage (RMM)	0.020	13
Uncontrolled Vapor Released (RMM)	0.036	9
Fire / Explosion (M)	0.010	16
Electricity	0.034	10
Violence and Robberies	0.005	18

(Importance, 0.036; Performance, 2.13), 'Fire / Explosion (M)' (Importance, 0.010; Performance, 2.89) and 'Violence and Robberies' (Importance, 0.005; Performance, 2.89). Factors that showed low importance with high performance were 'Overfill / Crossover' (Importance, 0.027; Performance, 4.11), 'Vehicular Impact' (Importance, 0.018; Performance, 4.04), 'Unauthorized personnel' (Importance, 0.018; Performance, 4.04) and 'Electricity' (Importance, 0.034; Performance, 3.60) (Fig. 5).

Although, this study is a comprehensive study, however, like other studies it has two main shortcomings. First, it uses data collected from only 3 districts of Punjab, Pakistan. Second, the statistical routines used in this study, i.e., fuzzy AHP and IPA also confer some disadvantages. For instance, the scale used in AHP is considered ridiculous occasionally by researchers. In addition, only definite figures are analyzed by using AHP method. Acquired results cannot be represented by numbers so use of AHP in such conditions is not accurate. Moreover, AHP routine trail stakeholder's priorities and ignores potential uncertainties.[39] Thus, based upon the findings of this study it is recommended to do further research on a larger scale by collecting data from larger area and involving more number of participants. Each risk type studies should be explored more in detail and to find ways to encounter it.

In order to further explore the impact of different regions on the results of fuzzy AHP and IPA, this paper used regional sensitivity analysis graphs (Fig. 6) to study the impacts of different region on the key indicators from the above analysis. The sequences of risk factors in different regions are the same, but the absolute value sequences of the same risk factor in different regions are different, so the impacts of different region might exist, but not affect the overall results.

It is a pilot study as the topic of this paper has been studied by a very less number of literatures. Thus, this study can be referenced by future related studies. However, use of fuzzy AHP and IPA analysis to risk prioritization and management in gas stations is regular in scientific published literature.

Limitations and Future Scope of Research

The limitations of this paper are: (1) Fuzzy AHP and IPA approach consider quantized data lesser. (2) Due to the complexity of phenomenon or people's one-sided understanding of phenomenon, the eigenvector (weight) might not be reasonable, but this is hard to make sure. (3) The data only included three districts in Pakistan.

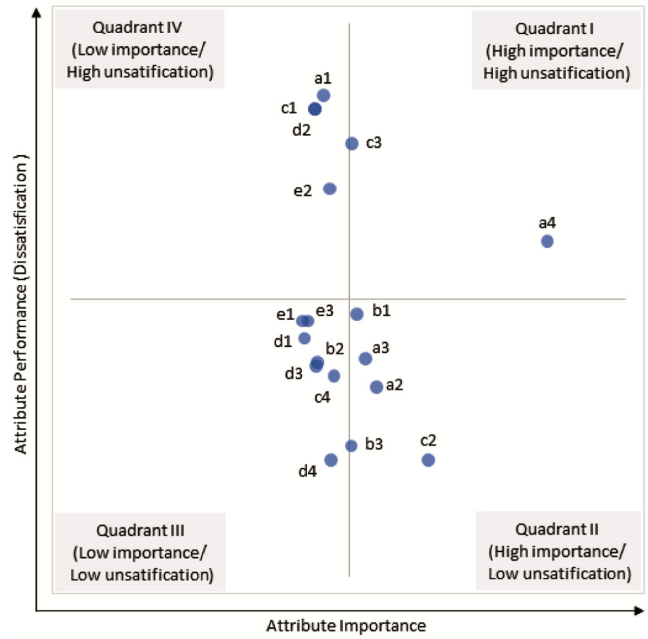

Fig. 5 — Estimated IPA results for importance and performance attributes

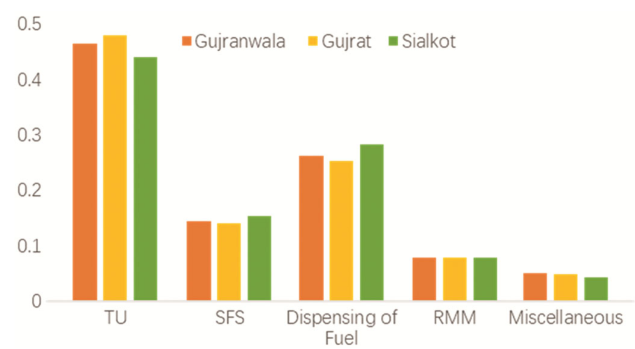

Fig. 6 — Estimated fuzzy AHP results for importance of risk factors in different regions (sensitivity analysis)

The future score of this paper are: (1) Fuzzy AHP and fuzzy multi-objective linear or non-linear programming could be used to study the related issues of this paper. (2) The comparison of the results in the period of COVID-19 and the period of post- COVID-19. (3) The data could expand to all districts in Pakistan.[40,41]

Conclusions

This study attempts to identify and prioritize various risks and their sub-types faced by gas stations in Pakistan. It analyzes statistical data fetched through questionnaire survey by famous routines of fuzzy AHP and IPA. This study concludes that gas stations are exposed to five main risk factors, viz., Transportation/Tanker Unloading (TU), Dispensing of Fuel, Storage of Fuel on Site (SFS), Repair, Maintenance or Modification (RMM) and Miscellaneous from the most important to least important factor in a chronological order. This study also identified risk-sub factors in each main risk factor and ranked all risk sub-factors. It is found that the most significant risk sub-factor is Driving carelessness / Accidents followed by Ignition Sources and Uncontrolled Vapor Released (TU). Furthermore, IPA ranked the most important factors for better management practices. It also presents shortcomings of this work. Based upon obtained results, this study proposes recommendations to encounter these risks. Thus, findings of this study are of practical importance and can be used as a reference for further in-depth research and policy modification or implementation to elevate existing situation of gas stations in Pakistan.

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Conflict of Interest Statement

Authors have no conflict of interest.

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