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Research Paper

A Novel Evaluation and Decision-Making Approach to Prioritizing the Service Quality Criteria in Road Transportation Systems

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Abstract

The passengers' expectations of road transportation systems' service quality lead transportation policy-makers to determine the technical requirements to meet these expectations. It means that Road trip Designs (RDs) as technical requirements should be translated based on Road users' Requirements (RRs) as passengers' expectations. We classified the RRs and RDs to 8 and 10 requirements, respectively. The Quality Function Deployment (QFD) method can translate the RRs to RDs in road transportation systems. On the one hand, due to the inherent uncertainty in decision-makers viewpoints in such systems, the Fuzzy QFD (FQFD) can be applied as a more accurate translation of RRs to RDs. On the other hand, the Evidential Reasoning (ER) approach, as one of the best evidence-based decision analysis methods, deals with the raised ambiguity and chaos by decision makers' viewpoints. Accordingly, a novel hybrid FQFD-ER approach to prioritize the service quality criteria in road transportation systems has been provided in this paper. Moreover, a novel mathematical lemma is provided to hybridize and link the decision-making approaches of the FQFD and ER. Considering the weights of decision makers and fuzzy trapezoidal numbers to achieve the better results are other innovations of this paper. Totally, this study aims to integrate the FQFD with the ER approach to prioritize the RDs based on RRs in related road transportation systems to the Arba'een ceremony as a real case study. The obtained results by hybrid FQFD-ER revealed that the suitable road lanes in terms of width and number mostly improve the service quality.

Keywords: Road Transportation Systems; Fuzzy Quality Function Deployment (FQFD); Road Users' Requirements (RRs); Evidential Reasoning (ER); Road Trip Designs (RDs)

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1. Introduction

An effective road transportation system with a reasonable travel time and optimal fuel consumption is an important prerequisite for socio-economic developments among countries. Therefore, the criteria of the service quality of the road transportation require much more attention, compared with rail and air transport systems. Subsequently, transportation authorities need to prioritize the RDs with respect to the RRs. In this way, a variety of qualitative techniques can be employed to prioritize the RDs. The QFD is one of the qualitative techniques, enabling the policy-makers to prioritize the RDs based on the RRs. The QFD translates the customers’ needs (Whats) to the design requirements (Hows). Considering the uncertainty aspect in the service quality of the road transportation systems, the FQFD can effectively tackle uncertainties using a five-point Likert-scale to a better reflection of the RDs based on RRs. The other aspects of service quality in mentioned systems are ambiguity and chaos. Accordingly, the ER can be a proper technique to deal with ambiguity and chaos for prioritizing the RDs of service quality in mentioned systems [Motevalli Habibi et al., 2021]. Evidential reasoning basically means reasoning with evidence [Srivastava, 2011]. The ER is a generic evidence-based decision analysis approach for dealing with problems with quantitative and qualitative criteria under ambiguity and chaos [Yang et al., 1994, Liu et al., 2004]. Therefore, this study aims to create a novel hybrid approach of FQFD and ER techniques as an efficient decision-making tool to prioritize the related RDs to service quality of the road transportation systems. The main questions of this paper are as follows: (1) what is the priority of each one of the RDs in road transportation systems' service quality? (2) What is the degree of preference for each one of the RDs compared with a lower-priority RD?

Despite the conducted works on FQFD, which didn’t consider the ambiguity and chaos aspects in the decision-making process, this paper removes the raised ambiguity and chaos by FQFD using ER. Moreover, an efficient Lemma converts the outputs of the FQFD to the inputs of the ER to find more accurate results. Finally, this paper not only considers the trapezoidal numbers, which give more accurate results than triangular numbers, but it also considers the weight of decision-makers. This study is organized as follows:

The literature review is provided in section 2. The mathematical formulation of the FQFD-ER technique is given in section 3. Section 4 implements FQFD-ER to prioritize the related RDs to service quality of the road transportation systems for Arba'een as the world′s largest pilgrimage. Sensitivity analyses, managerial implications, and conclusions are given in sections 5, 6, and 7 respectively

2. Literature Review

Operation research (OR) techniques have been widely applied in public transport management [Suman et al., 2017, Mavi et al., 2018, Mirzahossein et al., 2018, Afandizadeh et al., 2020]. Many transport researchers are interested in improving public transport quality by focusing on OR techniques, especially new decision-making approaches, to meet the passengers’ expectations [Agyeman and Cheng, 2020, Chauhan et al., 2021]. We classified the related works to FQFD and ER, which are carried out to assess the transportation sector in two subsections as follows:

2.1. FQFD to Assess the Transportation Sector

This subsection reviews and distinguishes the related works to FQFD, which are carried out to assess the transportation sector. In a paper, [Yamamoto et al., 2005] applied QFD to assess winter road maintenance services focusing on road user satisfaction. Although governments are responsible for winter road maintenance, the government's quality of service can be evaluated using the QFD. In another work, [Wang, 2007] employed QFD to improve the performance of China airlines. He provided a house of quality to recognize passengers' voice regarding services and technology operation. Then, [Chin et al., 2009] proposed a technique integrating QFD with ER approach. They found that the prioritization of design requirements based on customers' needs would be more specific. In an interesting study, [Lam, 2015] carried out a study to design a sustainable maritime supply chain using a hybrid QFD– analytic network process (ANP) approach. Later, [Lam and Bai, 2016] implemented QFD to study supply chain resilience focusing on the customers' needs and maritime natural and man-made hazards. In the following, [Asadamraji and Nahavandi, 2017] provided an efficient decision-making method for road sections' safety prioritization using six parameters, including number of accidents, road side conditions, traffic signs, road markings, pavement status, and access point density. In California, transportation infrastructure maintenance has been analyzed using the QFD [Bolar et al., 2017]. The road transportation service quality has been assessed based on documentaries, safety regulations, technical indexes, and passengers' viewpoints [Epifanov et al., 2018]. Later, [Li et al., 2019] investigated the risk of hazardous material transportation in an uncertain environment. For this purpose, they developed a semi-qualitative decision-making framework based on QFD and fuzzy analytical hierarchy process (FAHP). Finally, [Alkharabsheh et al., 2021] proposed a hybrid decision-making procedure to overcome the limitations of the uncertainty in the public transport system's supply quality evaluation. They estimated and ranked the public transport system's supply quality criteria by adopting the proposed procedure for a real-world case study.

2.2. ER Approach to Evaluate the Transportation Sector

This subsection reviews the related works to ER, which are applied to evaluate the transportation sector. In an interesting study, [Rassafi et al. 2018] assessed road safety performance as a complex decision-making problem. They also applied the ER approach to deal with the missing data. Later, [Zhao et al., 2019] integrated the ER approach with a genetic algorithm to optimize the bus deployment model. In another work, [Bappy et al., 2019] evaluated supply chain stability using a method based on the ER approach, Dempster-Shafer theory, and analytic hierarchy process. In the following, [Lam and Zhang, 2019] applied FQFD to enhance customer value in liner shipping. Then, [Chin et al., 2019] evaluated passengers' satisfaction using a hybrid QFD–ANP approach focusing on seat comfort and luggage storage in a high-speed rail system. Later, [Ganji and Rassafi, 2019] employed the ER approach to analyze road safety performance. Finally, [Pandey, 2020] employed FQFD to consider design requirements to meet passengers' expectations of low-cost airlines.

Table 1. Comparison among our FQFD-ER model and relevant models

Researcher(s)	The Applied/Hybridized Methods(s)								Weight of Decision Makers	Trapezoidal Fuzzy Numbers	Applied for RHDPT
	QFD	FQFD	ER	RM	GA	AHP	DEA	ANP			
[Ahmed et al., 2003]	✓										
[Yamamoto et al., 2005]	✓										
[Wang, 2007]	✓										
[SangChin et al., 2009]			✓								
[Lee Lam, 2014]	✓					✓					
[Lee Lam et al., 2016]	✓										
[Bolar et al., 2017]	✓										
[Suman et al., 2017]				✓							
[Lee Lam et al., 2018]		✓									
[Epifanov et al., 2018]	✓										

Researcher(s)	The Applied/Hybridized Methods(s)								Weight of Decision Makers	Trapezoidal Fuzzy Numbers	Applied for RHDPT
	QFD	FQFD	ER	RM	GA	AHP	DEA	ANP			
[Mavi et al., 2018]				✓							
[Sang Chin et al., 2019]	✓					✓					
[Lai Li et al., 2019]		✓				✓					
[Zhao et al., 2019]			✓		✓						
[Bappy et al., 2019]			✓			✓					
[Lam and Zhang, 2019]		✓									
[Mohan Pandey, 2020]		✓									
[Dabous et al. 2020]	✓			✓							
[Agyeman and Cheng, 2020]				✓							
[Chauhan et al. 2021]				✓							
[Our study]		✓	✓						✓	✓	✓

The literature of the study was demonstrated in Table 1. Obviously, there are gaps in previous studies. To the best of our knowledge, no study has considered a hybrid method integrating FQFD and ER approach. In addition, the weight of decision-makers has rarely been applied in RRs and RDs-RRs matrices. Furthermore, the proposed method applies trapezoidal fuzzy numbers (TFNs), while most previous studies have used triangular fuzzy numbers. It is also noteworthy that a mathematical Lemma is developed to convert the output of FQFD to the input of the ER approach for aggregation.

3. A Novel Hybrid Method of FQFD with ER Approach

In this section, a six-phase hybrid approach of FQFD with ER methods will be provided.

3.1. Notations

Following the used notations are presented as follow:

RR_i: i^{th} Road users' Requirement i=1,2, … ,m

RD_j: j^{th} Road trip Designs j=1,2, … ,n

DM_k: k^{th} decision-maker k=1,2, … ,p

W_k: The weight for k^{th} decision-maker k=1, 2, …, p

$\tilde{C}$ $(a_{ki}, b_{ki}, c_{ki}, d_{ki})$: TFNs which relates DM_k to RR_i

$\widetilde{WR_i}$ $(wr_{ia}, wr_{ib}, wr_{ic}, wr_{id})$: Fuzzy trapezoidal weight of RR_i

$\tilde{D}$ $(a_{kji}, b_{kji}, c_{kji}, d_{kji})$: TFN for comparing RD_j with respect to RR_i based on k^{th} decision maker's viewpoint

$\widetilde{WRP_{ji}}$ $(wrp_{jia}, wrp_{jib}, wrp_{jic}, wrp_{jid})$: The interactive weight between RDj and RRi

$\widetilde{WR_j}$ $(wr_{ja}, wr_{jb}, wr_{jc}, wr_{jd})$: Fuzzy trapezoidal weight for RD_j

$EV^L(RD_j)$: The infimum expected value of RD_j

$EV^U(RD_j)$: The supreme expected value of RD_j

LB_j: The lower bound of weight of RD_j using ER

UB_j: The upper bound of weight of RD_j using ER

BW_j: Belief weight of RD_j based on ER

FMW_j: Final weight of RD_j

3.2. FQFD-ER Approach

3.2.1. Step 1: The RRs (WHATs) and Their TWs

The parameters proposed in [Yamamoto et al., 2005] are summarized in Table 2. FQFD was employed to configure the relevant RRs based on the parameters as mentioned earlier.

Table 2. RRs for road transportation systems

No.	**Road users Requirements (WHATs)**	**Notations**
1	Level of Service	RR_1
2	Traffic Safety	RR_2
3	Road Climatic Conditions	RR_3
4	Travel Comfort and Tranquility	RR_4
5	Emergency/Logistic Center Facilities	RR_5
6	Design Speed Limit	RR_6
7	Road Furniture and the Beauty of the Roadside	RR_7
8	Weather Condition and Preparedness Slippery Road	RR_8

Then, the fuzzy trapezoidal weights of the RRs are computed using Equation 1 with respect to the weights of decision makers and TFNs.

$$\widetilde{WR_i}(wt_{ia}, wt_{ib}, wt_{ic}, wt_{id})\ , i = 1, 2, \dots, m \qquad (1)$$

Where,

$$wr_{ia} = \sum_{K=1}^{p} W_k * a_{ki} \qquad i = 1, 2, \dots, m \qquad (2)$$

$$wr_{ib} = \sum_{K=1}^{p} W_k * b_{ki} \qquad i = 1, 2, \dots, m \qquad (3)$$

$$wr_{ic} = \sum_{K=1}^{p} W_k * c_{ki} \qquad i = 1, 2, \dots, m \qquad (4)$$

$$wr_{id} = \sum_{K=1}^{p} W_k * d_{ki} \qquad i = 1, 2, \dots, m \qquad (5)$$

The importance of the RRs is determined using a set of five-point Likert scales (Very High, High, Medium, Low, and Very Low). Then relative TFNs can be obtained as follows:

VL: $(a_1, b_1, c_1, d_1) = (0, 1, 2, 3)$
L: $(a_2, b_2, c_2, d_2) = (1, 2, 3, 4)$
M: $(a_3, b_3, c_3, d_3) = (3, 4, 5, 6)$
H: $(a_4, b_4, c_4, d_4) = (5, 6, 7, 8)$
VH: $(a_5, b_5, c_5, d_5) = (6, 7, 8, 9)$

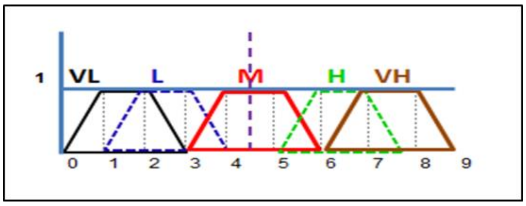

Figure 1. Membership Function for TFNs

Figure 1 shows the related membership functions

3.2.2. Step 2: Identifying the RDs (HOWs)

As demonstrated in Table 3, the relevant RDs are also configured based on the conceptual model provided by [Yamamoto et al., 2005].

Table 3. RDs for road transportation systems

Road maintenance Design (HOWs)	**Examples**	**Notations**
Suitable lanes	-Suitable width and number for easy pass from each other	RD_1
Traffic account	-Congestion	RD_2
Hot spot		RD_3
Execution of road	-Guardrail, Signs -Securing important fortifications and embankments outside the arches	RD_4
Intelligent Transportation System(ITS)	-Meteorology systems -Variable Message Sign(VMS)	RD_5

Road maintenance Design (HOWs)	Examples	Notations
	-Variable Speed Limited(VSL) -Speed camera -Enforcement camera	
Geometry road design	-Topography -Visibility	RD_6
International Roughness Index(IRI)	-Micro texture profile meter depth(MPD) -Pavement Condition Index(PCI)	RD_7
Welfare complex area	-Trucks parking	RD_8
Proper road maintenance operation	-Toll House and Salt storage -Frequency patrol of road machinery and presence of traffic agents	RD_9
Speed limit strategy		RD_{10}

3.2.3. Step 3: Interactive Weights of the RDs

A new matrix is constructed to demonstrate the relationships between RRs and RDs. Accordingly, the interactive weights of the RDs can be found using Equation 6 concerning the weights of decision-makers and TFNs.

$$\widetilde{WRP}_{ji} \quad (wrp_{jia}, wrp_{jib}, wrp_{jic}, wrp_{jid}) \qquad (6)$$
$$j = 1, 2, \dots, n \quad i = 1, 2, \dots, m$$

Where,

$$wrp_{jia} = \sum_{K=1}^{p} WV_k * a_{kji} \qquad (7)$$
$$j = 1, 2, \dots, n \qquad i = 1, 2, \dots, m$$

$$wrp_{jib} = \sum_{K=1}^{p} WV_k * b_{kji} \qquad (8)$$
$$j = 1, 2, \dots, n \qquad i = 1, 2, \dots, m$$

$$wrp_{jic} = \sum_{K=1}^{p} WV_k * c_{kji} \qquad (9)$$
$$j = 1, 2, \dots, n \quad i = 1, 2, \dots, m$$

$$wrp_{jid} = \sum_{K=1}^{p} WV_k * d_{kji} \qquad (10)$$
$$j = 1, 2, \dots, n \qquad i = 1, 2, \dots, m$$

3.2.4. Step 4: The Trapezoidal Weight of the RDs

The trapezoidal weights of the RDs are determined based on the obtained interactive weights of the RDs. The interactive weights of the RDs are converted to the trapezoidal weights using Equation 11.

$$\widetilde{WR}_j \quad (wr_{ja}, wr_{jb}, wr_{jc}, wr_{jd}) \qquad (11)$$
$$j = 1, 2, \dots, n$$

Where,

$$wr_{ja} = \sum_{i=1}^{m} wrp_{jia} \qquad (12)$$
$$j = 1, 2, \dots, n$$

$$wr_{jb} = \sum_{i=1}^{m} wrp_{jib} \qquad (13)$$
$$j = 1, 2, \dots, n$$

$$wr_{jc} = \sum_{i=1}^{m} wrp_{jic} \qquad (14)$$
$$j = 1, 2, \dots, n$$

$$wr_{jd} = \sum_{i=1}^{m} wrp_{jid} \qquad (15)$$
$$j = 1, 2, \dots, n$$

3.2.5. Step 5: Converting the Trapezoidal Weight of the RDs to Belief Structure of the ER

The trapezoidal weights of the RDs can be converted to the input of the ER approach. In other words, the trapezoidal weight of the RDs as the output of FQFD should be converted to the belief structures. For this purpose, an efficient Lemma is defined as Equation 16:

Lemma: If $\widetilde{A}$ (a, b, c, d) is a trapezoidal fuzzy number, then its BS will be as Equation 16:

$$\left\{\begin{matrix}\left(\boldsymbol{a-b}, \left(\frac{b-a}{c-b+d-a}\right)\right), \\ \left(\boldsymbol{b-c}, \left(\frac{2(c-b)}{c-b+d-a}\right)\right), \\ \left(\boldsymbol{c-d}, \left(\frac{d-c}{c-b+d-a}\right)\right)\end{matrix}\right\} \tag{16}$$

Proof: If $\widetilde{\mathrm{A}}$ (a, b, c, d) is a TFN (shown in Figure 2), then the related membership function will be as Equation 17:

$$\mu_{(\tilde{A})}(\mathrm{x}) = \begin{cases}\boldsymbol{a-b} & \left(\frac{x-a}{b-a}\right) \\ \boldsymbol{b-c} & 1 \\ \boldsymbol{c-d} & \left(\frac{x-d}{c-d}\right)\end{cases} \tag{17}$$

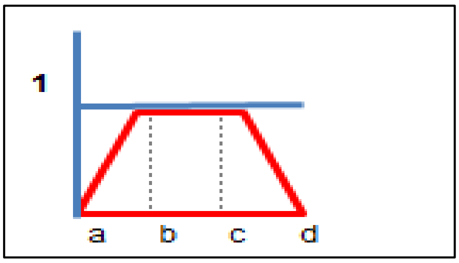

Figure 2. Membership Function for a TFN

Since, the summation of the belief degrees in the ER approach must be equal to one, we should normalize the membership degrees of TFN $(\widetilde{\mathrm{A}})$. To do so, the summation of membership degrees of TFN $(\widetilde{\mathrm{A}})$ should be calculated, and then the membership degree in each span of (a-b, b-c, c-d) should be divided by summation of membership degrees, as shown in Equation 18.

$$\left(\frac{\frac{x-a}{b-a}}{\frac{x-a}{b-a}+1+\frac{x-d}{c-d}}, \frac{1}{\frac{x-a}{b-a}+1+\frac{x-d}{c-d}}, \frac{\frac{x-d}{c-d}}{\frac{x-a}{b-a}+1+\frac{x-d}{c-d}}\right) \tag{18}$$

Final output in Equation 18 can be shown in Equation 19.

$$\left(t = \frac{(x-a)(c-d)}{(x-a)(c-d)+(b-a)(c-2d+x)}, u = \frac{(b-a)(c-d)}{(x-a)(c-d)+(b-a)(c-2d+x)}, v = \frac{(x-d)(b-a)}{(x-a)(c-d)+(b-a)(c-2d+x)}\right) \tag{19}$$

Based on Equation 19, the BS in three spans (a-b, b-c, c-d) can be calculated using Equations 20, 21, and 22, respectively.

$$\int_a^b t\, d(x) = \frac{b-a}{c-b+d-a} \tag{20}$$

$$\int_b^c u\, d(x) = \frac{2(c-b)}{c-b+d-a} \tag{21}$$

$$\int_c^d v\, d(x) = \frac{(d-c)}{c-b+d-a} \tag{22}$$

The provided structure in Equations 20 to 22 is the same BS in three spans (a-b, b-c and c-d) in Equation 16. The lemma has been proved. Based on the proposed lemma (Equation 16), the trapezoidal weight of the RDs can be converted to BS as shown in Equation 23.

$$\left\{\begin{matrix}\left(wr_{ja}-wr_{jb}, \left(\frac{wr_{jb}-wr_{ja}}{wr_{jc}-wr_{jb}+wr_{jd}-wr_{ja}}\right)\right), \\ \left(wr_{jb}-wr_{jc}, \left(\frac{2(wr_{jc}-wr_{jb})}{wr_{jc}-wr_{jb}+wr_{jd}-wr_{ja}}\right)\right), \\ \left(wr_{jc}-wr_{jd}, \left(\frac{(wr_{jd}-wr_{jc})}{wr_{jc}-wr_{jb}+wr_{jd}-wr_{ja}}\right)\right)\end{matrix}\right\} \tag{23}$$

$j = 1, 2, \ldots, n$

The lemma is actually a connector between FQFD and ER, which converts TFNs to BS.

3.2.6. Step 6: Priority and Superiority of the RDs

RDs are finally prioritized using the obtained BS. Moreover, the superiority of the RDs is formulated. Based on the ER approach and the obtained BS, the infimum and supreme expected values of the RDs can be formulated using Equations 24 and 25 as follows:

$$\mathrm{EV}^{\mathrm{L}}(RD_j) = wr_{ja} * \left(\frac{wr_{jb}-wr_{ja}}{wr_{jc}-wr_{jb}+wr_{jd}-wr_{ja}}\right) + wr_{jb} * \tag{24}$$

$$\left(\frac{2(wr_{jc}-wr_{jb})}{wr_{jc}-wr_{jb}+wr_{jd}-wr_{ja}}\right)+wr_{jc}*\left(\frac{(wr_{jd}-wr_{jc})}{wr_{jc}-wr_{jb}+wr_{jd}-wr_{ja}}\right)$$
$$j=1,2,\ldots,n$$

$$\mathrm{EV}^{\mathrm{U}}(RD_j)=wr_{jb}*\left(\frac{wr_{jb}-wr_{ja}}{wr_{jc}-wr_{jb}+wr_{jd}-wr_{ja}}\right)+wr_{jc}*\left(\frac{2(wr_{jc}-wr_{jb})}{wr_{jc}-wr_{jb}+wr_{jd}-wr_{ja}}\right)+wr_{jd}*\left(\frac{(wr_{jd}-wr_{jc})}{wr_{jc}-wr_{jb}+wr_{jd}-wr_{ja}}\right)\quad(25)$$
$$j=1,2,\ldots,n$$

The belief weight of the RDs can be calculated using Equation 26:

$$BW_j\left(LB_j,UB_j\right)\quad(26)$$
$$j=1,2,\ldots,n$$

Where, the lower and upper bounds of weight of the RDs (LB_j,UB_j) can respectively be obtained using Equations 27 and 28.

$$LB_j=\frac{\mathrm{EV}^{\mathrm{L}}(\mathrm{RD}_j)}{\mathrm{EV}^{\mathrm{L}}(\mathrm{RD}_j)+\sum_{j=1}^{n\neq j}\mathrm{EV}^{\mathrm{U}}(\mathrm{RD}_j)}\quad(27)$$
$$j=1,2,\ldots,n$$

$$UB_j=\frac{\mathrm{EV}^{\mathrm{U}}(\mathrm{RD}_j)}{\mathrm{EV}^{\mathrm{U}}(\mathrm{RD}_j)+\sum_{j=1}^{n\neq j}\mathrm{EV}^{\mathrm{L}}(\mathrm{RD}_j)}\quad(28)$$
$$j=1,2,\ldots,n$$

Each RD can be prioritized using Equation 29.

$$FMW_j=\frac{LB_j+UB_j}{\sum_{j=1}^{n}LB_j+UB_j}\quad(29)$$
$$j=1,2,\ldots,n$$

The superiority or degree of preference for each RD compared with RD with lower priority can be calculated as follow (Wang et al. 2005):

$$P(RD_j>RD_l)=\frac{max(0,UB_j-LB_l)-max(0,LB_j-UB_l)}{(UB_j-LB_j)+(UB_l-LB_l)}\quad(30)$$
$$j=1,2,\ldots,n\quad l=1,2,\ldots,n\quad(j\neq l)$$

4. Case Study: Arba'een's Road Transportation Trips

In Arba'een ceremony as the world′s largest pilgrimage, many pilgrims should be transported in a short period of time. Statistical data demonstrated that more than six million trips were made in the Arba'een ceremony in 2019. Due to the significant road congestion in this ceremony, Iran's policy makers should improve the service quality of the involved road transportation systems. In fact, it has been proved that a higher satisfaction rate of the service quality can be achieved through the road transportation systems. Accordingly, identifying and prioritizing the RRs and their related RDs are very important and inevitable for appropriate policy making. To this end, the proposed FQFD-ER technique is implemented to identify the relevant RRs and RDs. Then, the RDs are prioritized.

4.1. Step 1

As shown in Table 2, the RRs are identified based on proposed framework by [Yamamoto et al., 2005]. The weights of the RRs are calculated using Equations 1 to 5. The results are shown in Table 4.

Table 4. The RWs of RRs

RR$_i$	**Trapezoidal Weights of RRs ($\widetilde{WR_i}$)**			
RR$_1$	(5.10,	6.10,	7.10,	8.10)
RR$_2$	(5.80,	6.80,	7.80,	8.80)
RR$_3$	(3.16,	4.16,	5.16,	6.16)
RR$_4$	(5.78,	6.78,	7.78,	8.78)
RR$_5$	(4.90,	5.90,	6.90,	7.90)
RR$_6$	(3.27,	4.27,	5.27,	6.27)
RR$_7$	(3.39,	4.39,	5.39,	6.39)
RR$_8$	(4.57,	5.57,	6.57,	7.57)

The data were collected using questionnaires distributed among transportation experts involved in the road transportation trips of the Arba'een pilgrimage. The reliability of these questionnaires is presented in Table 5.

Table 5. The reliability of the RDs based on Cronbach's alpha test

RD_j	Cronbach's alpha test result
RD_1	0.719
RD_2	0.707
RD_3	0.821
RD_4	0.701
RD_5	0.855
RD_6	0.720
RD_7	0.731
RD_8	0.752
RD_9	0.787
RD_{10}	0.716

4.2. Step 2

As shown in Table 3, the relevant RDs are configured with respect to the identified RRs.

4.3. Steps 3 and 4

The trapezoidal weights of the RDs are calculated using Equations 11 to 15 as shown in Tables 6 and 7. Moreover, the interactive weights were calculated using Equations 6 to 10 as shown in Figure 3.

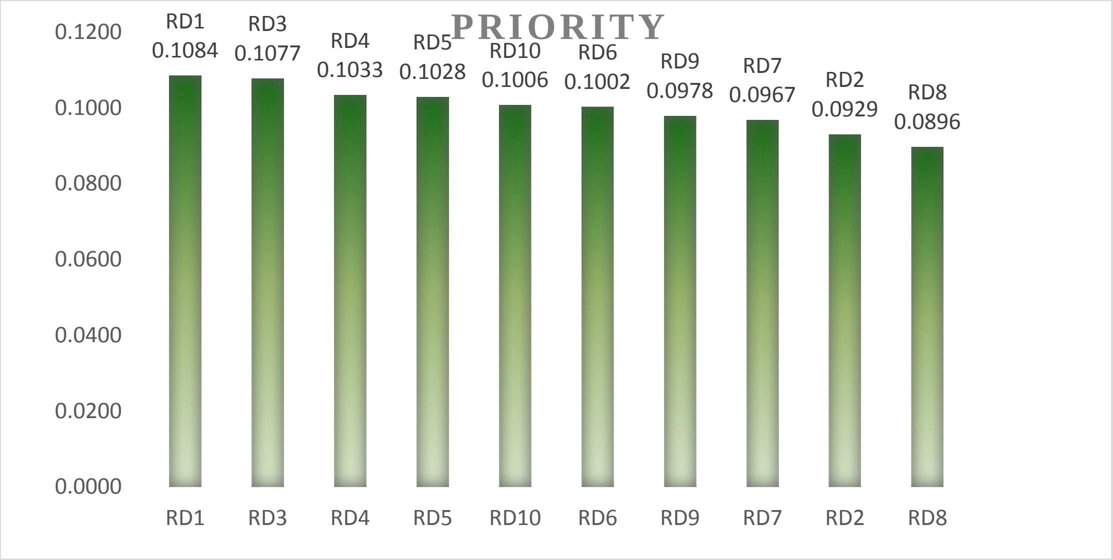

Figure 3. The priority of the RDs in Arba’een pilgrimage trip

Table 6. The interactive weights between each one of the RDs and the RRs

RD_1	RR1	5/50	6/50	7/50	8/50
	RR2	5/73	6/73	7/73	8/73
	RR3	3/71	4/71	5/71	6/71
	RR4	4/87	5/87	6/87	7/87
	RR5	2/96	3/96	4/96	5/96
	RR6	3/56	4/56	5/56	6/56
	RR7	1/81	2/81	3/81	4/81
	RR8	6/00	7/00	8/00	9/00
RD_2	RR1	4/75	5/75	6/75	7/75
	RR2	2/67	3/67	4/67	5/67
	RR3	3/03	4/03	5/03	6/03
	RR4	3/95	4/95	5/95	6/95
	RR5	5/69	6/69	7/69	8/69
	RR6	4/61	5/61	6/61	7/61
	RR7	3/95	4/95	5/95	6/95
	RR8	5/73	6/73	7/73	8/73
RD_3	RR1	6/00	7/00	8/00	9/00
	RR2	4/22	5/22	6/22	7/22
	RR3	3/79	4/79	5/79	6/79
	RR4	5/47	6/47	7/47	8/47
	RR5	3/68	4/68	5/68	6/68
	RR6	4/02	5/02	6/02	7/02
	RR7	1/96	2/96	3/96	4/96
	RR8	4/64	5/64	6/64	7/64
RD_4	RR1	3/20	4/20	5/20	6/20
	RR2	6/00	7/00	8/00	9/00
	RR3	3/19	4/19	5/19	6/19
	RR4	4/02	5/02	6/02	7/02
	RR5	3/70	4/70	5/70	6/70
	RR6	5/02	6/02	7/02	8/02
	RR7	3/21	4/21	5/21	6/21
	RR8	3/59	4/59	5/59	6/59
RD_5	RR1	4/84	5/84	6/84	7/84
	RR2	5/33	6/33	7/33	8/33
	RR3	3/81	4/81	5/81	6/81
	RR4	2/69	3/69	4/69	5/69
	RR5	3/99	4/99	5/99	6/99
	RR6	4/58	5/58	6/58	7/58
	RR7	1/71	2/71	3/71	4/71
	RR8	4/75	5/75	6/75	7/75
RD_6	RR1	5/84	6/84	7/84	8/84
	RR2	5/78	6/78	7/78	8/78
	RR3	3/50	4/50	5/50	6/50
	RR4	4/40	5/40	6/40	7/40
	RR5	1/96	2/96	3/96	4/96
	RR6	5/47	6/47	7/47	8/47

	RR7	0/89	1/89	2/89	3/89
	RR8	2/76	3/76	4/76	5/76
RD₈	RR1	4/17	5/17	6/17	7/17
	RR2	5/78	6/78	7/78	8/78
	RR3	1/82	2/82	3/82	4/82
	RR4	5/78	6/78	7/78	8/78
	RR5	1/47	2/47	3/47	4/47
	RR6	4/20	5/20	6/20	7/20
	RR7	1/31	2/31	3/31	4/31
	RR8	4/57	5/57	6/57	7/57
RD₈	RR1	2/85	3/85	4/85	5/85
	RR2	4/26	5/26	6/26	7/26
	RR3	3/00	4/00	5/00	6/00
	RR4	5/19	6/19	7/19	8/19
	RR5	4/71	5/71	6/71	7/71
	RR6	1/11	2/11	3/11	4/11
	RR7	3/37	4/37	5/37	6/37
	RR8	1/56	2/56	3/56	4/56
RD₉	RR1	3/62	4/62	5/62	6/62
	RR2	5/16	6/16	7/16	8/16
	RR3	4/24	5/24	6/24	7/24
	RR4	2/82	3/82	4/82	5/82
	RR5	5/78	6/78	7/78	8/78
	RR6	1/70	2/70	3/70	4/70
	RR7	1/69	2/69	3/69	4/69
	RR8	4/57	5/57	6/57	7/57
RD₁₀	RR1	5/69	6/69	7/69	8/69
	RR2	4/79	5/79	6/79	7/79
	RR3	3/44	4/44	5/44	6/44
	RR4	3/93	4/93	5/93	6/93
	RR5	1/50	2/50	3/50	4/50
	RR6	5/78	6/78	7/78	8/78
	RR7	1/00	2/00	3/00	4/00
	RR8	4/64	5/64	6/64	7/64

Table 7. The Trapezoidal Weights of the RDs

RD_j	**The Trapezoidal Weights of RDs ($\widetilde{WR_j}$)**			
RD_1	(34.13,	42.13,	50.13,	58.13)
RD_2	(17.70,	42.37,	50.37,	58.37)
RD_3	(33.79,	41.79,	49.79,	57.79)
RD_4	(31.93,	39.93,	47.93,	55.93)
RD_5	(31.71,	39.71,	47.71,	55.71)
RD_6	(30.60,	38.60,	46.60,	54.60)
RD_7	(29.10,	37.10,	45.10,	53.10)
RD_8	(26.05,	34.05,	42.05,	50.05)
RD_9	(29.58,	37.58,	45.58,	53.58)

RD_j	**The Trapezoidal Weights of RDs ($\widetilde{WR_j}$)**			
RD_{10}	(30.78,	38.78,	46.78,	54.78)

4.4. Step 5, 6

Based on Table 8, the trapezoidal weights of the RDs are converted to the BS of ER approach. Moreover, the infimum and supreme expected values for RDs are obtained using Equations 24 and 25, respectively. The RDs are then prioritized.

Table 8. The infimum/supreme expected values of the RDs and the BS of ER

RD_j	**The supreme expected values**	**The infimum expected values**	**The BS of ER for RDs**
RD_1	$\mathrm{EV^U(RD_1)}$= 50.13	$\mathrm{EV^L(RD_1)}$= 42.13	$\{(34.10-42.10, 0.25), (42.12-50.12, 0.50), (50.12-58.12, 0.25)\}$
RD_2	$\mathrm{EV^U(RD_2)}$= 47.63	$\mathrm{EV^L(RD_2)}$= 31.18	$\{(17.70-42.37, 0.51), (42.37-50.37, 0.33), (50.37-58.37, 0.16)\}$
RD_3	$\mathrm{EV^U(RD_3)}$= 49.79	$\mathrm{EV^L(RD_3)}$= 41.79	$\{(33.79-41.79, 0.25), (41.79-49.79, 0.50), (49.79-57.79, 0.25)\}$
RD_4	$\mathrm{EV^U(RD_4)}$= 47.93	$\mathrm{EV^L(RD_4)}$= 39.93	$\{(31.92-39.92, 0.25), (39.92-47.92, 0.50), (47.92-55.92, 0.25)\}$
RD_5	$\mathrm{EV^U(RD_5)}$= 47.71	$\mathrm{EV^L(RD_5)}$= 39.71	$\{(31.71-39.71, 0.25), (39.71-47.71, 0.50), (47.71-55.71, 0.25)\}$
RD_6	$\mathrm{EV^U(RD_6)}$= 46.60	$\mathrm{EV^L(RD_6)}$= 38.60	$\{(30.06-38.60, 0.25), (38.6-46.6, 0.50), (46.6-54.6, 0.25)\}$
RD_7	$\mathrm{EV^U(RD_7)}$= 45.10	$\mathrm{EV^L(RD_7)}$= 37.10	$\{(29.06-37.10, 0.25), (37.10-45.10, 0.50), (45.10-53.10, 0.25)\}$
RD_8	$\mathrm{EV^U(RD_8)}$= 42.05	$\mathrm{EV^L(RD_8)}$= 34.05	$\{(26.05-34.05, 0.25), (34.05-42.05, 0.50), (42.05-50.05, 0.25)\}$
RD_9	$\mathrm{EV^U(RD_9)}$= 45.58	$\mathrm{EV^L(RD_9)}$= 37.58	$\{(29.57-37.57, 0.25), (37.58-45.58, 0.50), (45.58-53.58, 0.25)\}$
RD_{10}	$\mathrm{EV^U(RD_{10})}$= 46.78	$\mathrm{EV^L(RD_{10})}$= 38.78	$\{(30.77-38.77, 0.25), (38.78-46.78, 0.50), (46.78-54.78, 0.25)\}$

Table 9 shows the lower bound, upper bound, and final weights of the RDs calculated using Equations 24 to 29.

Table 9. The lower and upper bounds of the weights of RDs

RD_j	**Lower bound of RDs**	**Upper bound of RDs**	**The final weight (Priority)**
RD_1	LB_1=0.091	UB_1=0.129	*0.110*
RD_2	LB_2=0.069	UB_2=0.120	*0.093*
RD_3	LB_3=0.091	UB_3=0.128	*0.108*
RD_4	LB_4=0.087	UB_4=0.123	*0.104*
RD_5	LB_5=0.086	UB_5=0.123	*0.103*
RD_6	LB_6=0.084	UB_6=0.120	*0.100*
RD_7	LB_7=0.080	UB_7=0.116	*0.097*
RD_8	LB_8=0.074	UB_8=0.108	*0.090*
RD_9	LB_9=0.081	UB_9=0.117	*0.098*
RD_{10}	LB_{10}=0.084	UB_{10}=0.120	*0.101*

Equation 31 extracted from the Table 9, shows the priority of the RDs during the Arba'een ceremony. Figure 3 illustrates the portion of the RDs during the Arba'een ceremony.

$$\begin{aligned} RD_1 > RD_3 > RD_4 > RD_5 > RD_{10} > RD_6 \\ > RD_9 > RD_7 > RD_2 \\ > RD_8 \end{aligned} \tag{31}$$

To this end, each the superiority (or preference degree) of the RDs compared with the RD with lower priority should be calculated using

Equation 30. Equation 32 shows the superiority of the RDs.

$$RD_1^{0.511} > RD_3^{0.560} > RD_4^{0.507} > RD_5^{0.530} > RD_{10}^{0.506} > RD_6^{0.534} > RD_9^{0.516} > RD_7^{0.544} > RD_2^{0.540} > RD_8 \quad (32)$$

Table 10 and Figure 4 demonstrate the superiority of the RDs.

Table 10. The superiority of the RDs compared with RDs with lower priorities

RD_j	Degree of preferences
RD_1	*0.511*
RD_3	*0.560*
RD_4	*0.507*
RD_5	*0.530*
RD_{10}	*0.506*
RD_6	*0.534*
RD_9	*0.516*
RD_7	*0.544*
RD_2	*0.540*
RD_8	-

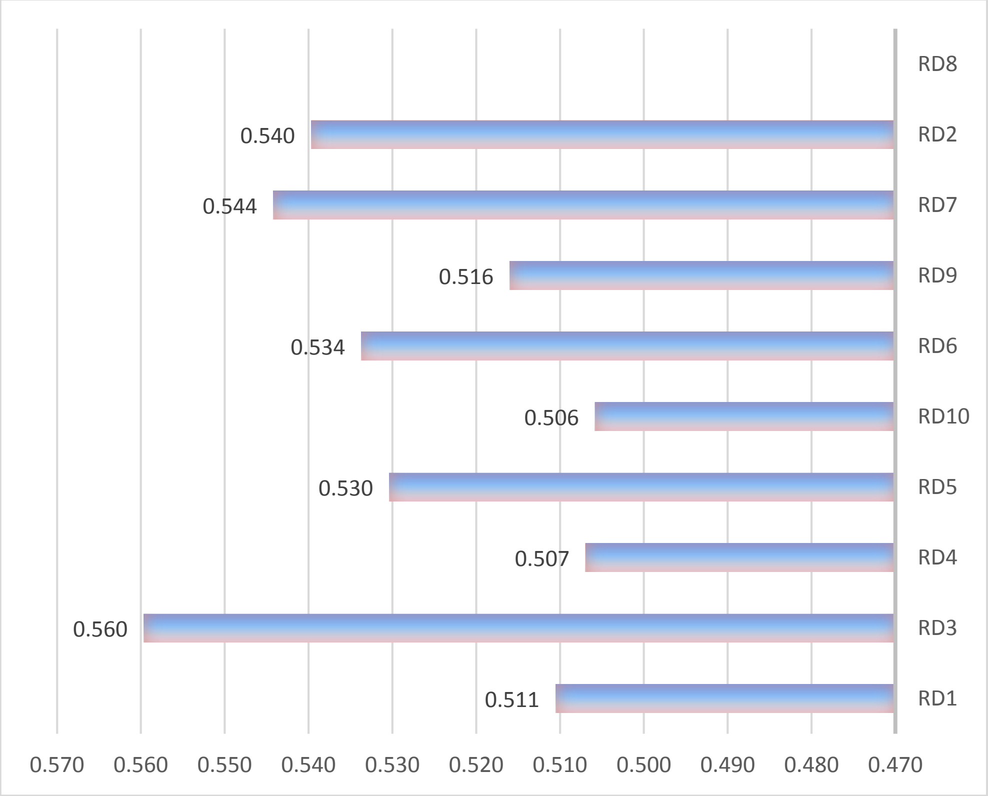

Figure 4. The superiority of the RDs compared with low-priority RDs

5. Sensitivity Analyses

In this section, the sensitivity analyses of the RDs are conducted according to the changes in the weights of decision-makers. Considering the equal weights for policy makers' opinions, the obtained results will be unrealistic. Weights of decision-makers enrich the FQFD-ER technique according to their skills and experiences. The sensitivity analyses are conducted to prioritize the RDs based on different scenarios. Accordingly, five scenarios are provided as follows:

5.1. Scenario 1

The maximum weight of 0.4 is assigned to the Iranian deputy minister of roads and urban development (President of the RMTO). In contrast, the weight of 0.15 is assigned to the rest of authorities. Equation 33 prioritizes the RDs based on this scenario.

$$\begin{aligned} RD_3^{0.505} > RD_1^{0.506} > RD_5^{0.574} > RD_4^{0.515} \\ > RD_{10}^{0.503} > RD_6^{0.535} \\ > RD_9^{0.542} > RD_7^{0.516} \\ > RD_2^{0.555} > RD_8 \end{aligned} \tag{33}$$

Figures 5 and 6 respectively show the priority and superiority of the RDs based on the first scenario.

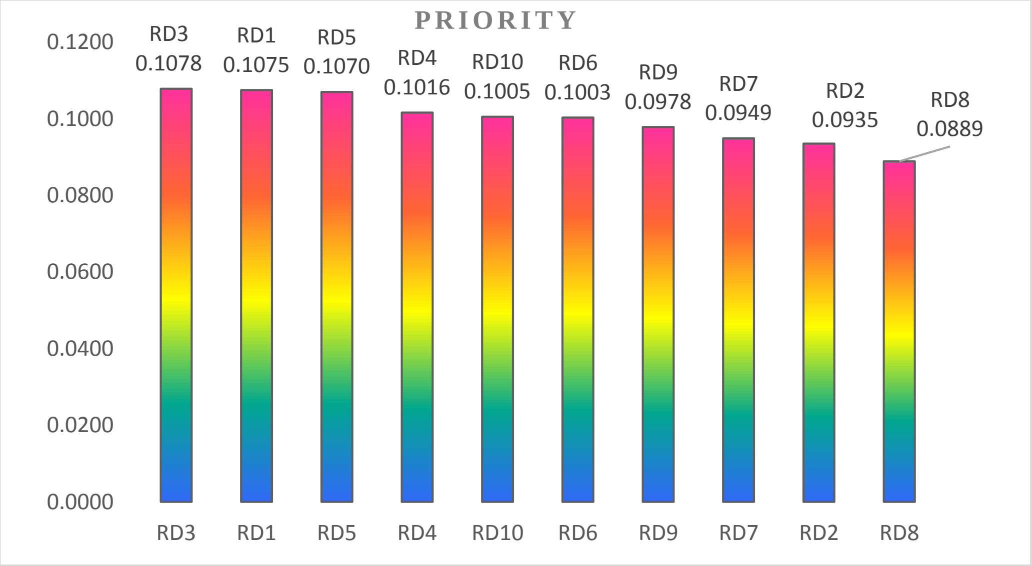

Figure 5. The priority of the RDs for Arba'een pilgrimage in first scenario

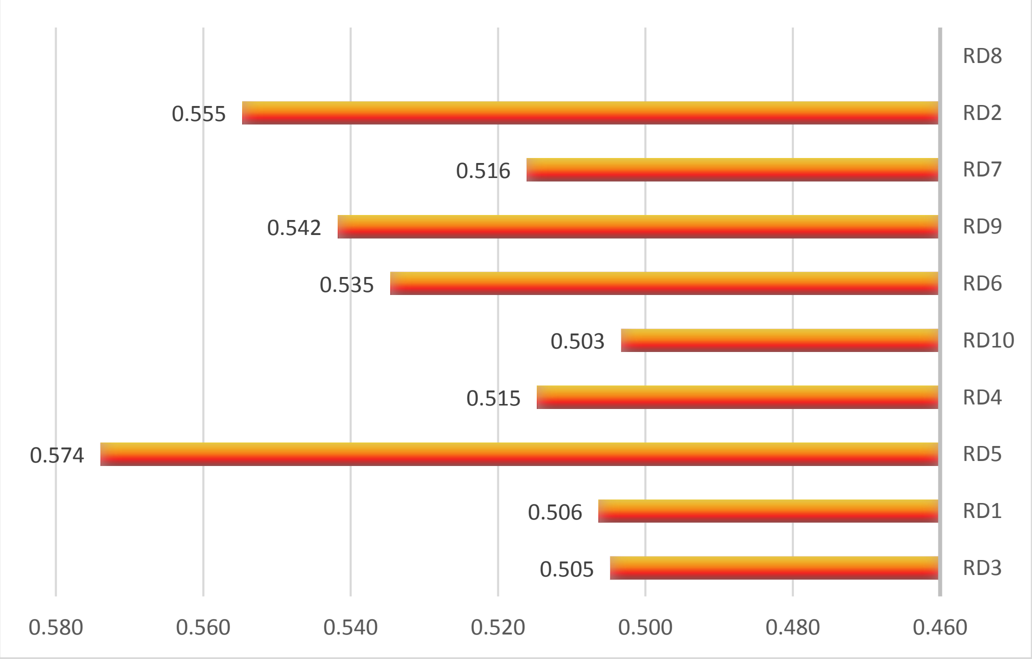

Figure 6. The superiority of the RDs for Arba'een pilgrimage in the first scenario

5.2. Scenario 2

The maximum weight of 0.4 is assigned to the road maintenance deputy of RMTO, while the weight of 0.15 is assigned to the rest of authorities. Equation 34 prioritizes the RDs based on this scenario.

$$\begin{aligned} RD_1^{0.511} > RD_3^{0.513} > RD_4^{0.506} > RD_5^{0.528} \\ > RD_6^{0.521} > RD_{10}^{0.547} \\ > RD_7^{0.517} > RD_9^{0.513} \\ > RD_2^{0.560} > RD_8 \end{aligned} \tag{34}$$

5.3. Scenario 3

The maximum weight of 0.4 is assigned to the director general of the department of road and rights of way development, while the weight of 0.15 is assigned to the rest of the authorities. Equation 35 prioritizes RDs based on this scenario.

$$\begin{aligned} RD_1^{0.575} > RD_3^{0.511} > RD_5^{0.510} > RD_4^{0.542} \\ > RD_6^{0.513} > RD_{10}^{0.538} \\ > RD_9^{0.500} > RD_7^{0.522} \\ > RD_2^{0.586} > RD_8 \end{aligned} \tag{35}$$

5.4. Scenario 4

The maximum weight of 0.4 is assigned to the director general of department of crisis management and roads machinery, while the weight of 0.15 is assigned to the rest of the authorities. Equation 36 prioritizes RDs based on this scenario.

$$\begin{aligned} RD_1^{0.527} > RD_3^{0.537} > RD_4^{0.539} > RD_{10}^{0.544} \\ > RD_6^{0.527} > RD_9^{0.500} \\ > RD_7^{0.512} > RD_5^{0.540} \\ > RD_2^{0.529} > RD_8 \end{aligned} \tag{36}$$

5.5. Scenario 5

The maximum weight of 0.4 is assigned to the director general of the department of Investment affairs and inter-city welfare complexes, while the weight of 0.15 is assigned to the rest of the authorities. Equation 37 prioritizes RDs based on this scenario.

$$\begin{aligned} RD_1^{0.519} > RD_3^{0.536} > RD_4^{0.549} > RD_6^{0.505} \\ > RD_5^{0.505} > RD_7^{0.524} \\ > RD_9^{0.511} > RD_{10}^{0.589} \\ > RD_2^{0.507} > RD_8 \end{aligned} \tag{37}$$

6. Managerial Implication and Insights

In this section, the managerial implications and insights are provided based on the results of sensitivity analyses. Due to the results of the present study and sensitivity analysis, all players involved in road transportation systems should pay attention to the following issues for improving the service quality:

The most important RDs are suitable lanes and Hot spot. These RDs have always two first priorities in road transportation systems even after changing the weights of decision-makers. Accordingly, it is strongly recommended to modifying the Hot spots and improving the lanes quality as most important priorities in order to significantly promote the service quality criteria in road transportation systems. The next priorities are execution of road and ITS. Therefore, adequate attention to ITS infrastructure plays a significant role in improving the service quality criteria in road transportation systems. Finally, the degree of preference for each one of the RDs comparing with the lower ones can help the transportation managers in case of changing the RD’s degree of preference for a possible necessity.

7. Conclusions

This paper proposed a novel hybrid technique integrating FQFD and the ER approach to prioritize the RDs in service quality of the road transportation systems taking into account the RRs. The trapezoidal weights of the RDs are computed through the first four steps of FQFD-ER approach. A mathematical Lemma converted the output of the FQFD to the BS in the fifth step. Actually, the Lemma linked the FQFD to ER by converting the trapezoidal weights of the RDs to BS of ER to find the priority and superiority of the RDs. As a real case study, the provided FQFD-ER approach was implemented to prioritize the RDs according to the Arba'een ceremony. Five scenarios were analyzed based on the different weights for the decision-makers. The policy makers recommended focusing on the road lane width for further improvement as the most important priority. The second priority was to mitigate the road black spot properly. The rest of the RDs were respectively prioritized as follows: appropriate safety equipment, intelligent transportation systems, road geometry design, International Roughness Index (IRI), proper road maintenance operation, appropriate intercity welfare complexes, traffic management and speed limit strategy. Accordingly, the designed FQFD-ER removed the uncertainty, chaos, and ambiguity resulted from expert’s subjective viewpoints. It provided a new decision-making tool for the Arba'een ceremony policy makers to prioritize the RDs in related road transportation trips to this ceremony.

8. References

-Ahmed, S. M., Sang, L. P., & Torbica, Ž. M. (2003). Use of Quality Function Deployment in Civil Engineering Capital Project Planning. Journal of Construction Engineering and Management, 129(4). 358–368, doi:10.1061/(asce)0733-9364(2003)129:4(358).

-Afandizadeh Zargari, S., & Safari, F. (2020). Using clustering methods in multinomial logit model for departure time choice. Journal of Advanced Transportation, 2020. doi:10.1155/2020/7382569.

-Agyeman, S., & Cheng, L. (2020). Analysis of barriers to perceived service quality in Ghana: Students’ perspectives on bus mobility attributes. Transport Policy, 99, 63-85. doi:10.1016/j.tranpol.2020.08.015.

-Alkharabsheh, A., Moslem, S., Oubahman, L., & Duleba, S. (2021). An integrated approach of multi-criteria decision-making and grey theory for evaluating urban public transportation systems. Sustainability, 13(5), 2740. doi: 10.3390/su13052740.

-Asadamraji, M., & Nahavandi, N. (2017). Ranking pattern of safety in rural road using a combination of Accident Severity Index and safety audit. Quarterly Journal of Transportation Engineering, 9(1), 1-15.

-Bappy, M. M., Ali, S. M., Kabir, G., & Paul, S. K. (2019). Supply chain sustainability assessment with Dempster-Shafer evidence theory: Implications in cleaner production. Journal of Cleaner Production, 237, 117771. doi:10.1016/j.jclepro.2019.117771.

-Bolar, A. A., Tesfamariam, S., & Sadiq, R. (2017). Framework for prioritizing infrastructure user expectations using Quality Function Deployment (QFD). International Journal of Sustainable Built Environment, 6(1), 16–29. doi.org/10.1016/j.ijsbe.2017.02.002.

-Chauhan, V., Gupta, A. & Parida, M. (2021). Demystifying service quality of Multimodal Transportation Hub (MMTH) through measuring users’ satisfaction of public transport. Transport Policy, 102, 47-60. doi.org/10.1016/j.tranpol.2021.01.004.

-Chin, K. S., Wang, Y. M., Yang, J. B., & Poon, K. K. G. (2009). An evidential reasoning based approach for quality function deployment under uncertainty. Expert Systems with Applications, 36(3), 5684-5694. doi.org/10.1016/j.eswa.2008.06.104.

-Chin, K. S., Yang, Q., Chan, C. Y., Tsui, K. L., & Li, Y. L. (2019). Identifying passengers' needs in cabin interiors of high-speed rails in China using quality function deployment for improving passenger satisfaction. Transportation Research Part A: Policy and Practice, 119, 326-342.doi.org/10.1016/j.tra.2018.12.004.

-Dabous, S. A., Al-Khayyat, G., & Feroz, S. (2020). Utility-Based Road Maintenance Prioritization Method Using Pavement Overall Condition Rating. The Baltic Journal of Road and Bridge Engineering, 15(1), 126-146 .doi: 10.7250/bjrbe.2020-15.464.

-Epifanov, V., Obshivalкin, M., & Lukonkina, K. (2018). Management of quality and security level of transportation in the system of regular passenger motor transport. Transportation Research Procedia, 36, 141–148. doi.org/10.1016/j.trpro.2018.12.056.

-Ganji, S. S. & Rassafi, A. A. (2018). Measuring the road safety performance of Iranian provinces: a double-frontier DEA model and evidential reasoning approach. International Journal of Injury Control and Safety Promotion, 26(2), 156-169 .doi.org/10.1080/17457300.2018.1535510

-Lam, J. S. L. (2015). Designing a sustainable maritime supply chain: A hybrid QFD–ANP approach. Transportation Research Part E: Logistics and Transportation Review, 78, 70-81. doi.org/10.1016/j.tre.2014.10.003.

-Lam, J. S. L., & Bai, X. (2016). A quality function deployment approach to improve maritime supply chain resilience. Transportation Research Part E: Logistics and Transportation Review, 92, 16-27. doi.org/10.1016/j.tre.2016.01.012.

-Lam, J. S. L., & Zhang, X. (2019). Innovative solutions for enhancing customer value in liner shipping. Transport Policy, 82, 88-95. doi.org/10.1016/j.tranpol.2018.09.001.

-Li, Y.-L., Yang, Q., & Chin, K.-S. (2019). A decision support model for risk management of hazardous materials road transportation based on quality function deployment. Transportation Research Part D: Transport and Environment, 74,154–173.
doi.org/10.1016/j.trd.2019.07.026.

-Liu, J., Yang, J. B., Wang, J., SII, H. S., & Wang, Y. M. (2004). Fuzzy rule-based evidential reasoning approach for safety analysis. International Journal of General Systems,33(2-3),183-204.doi.org/10.1080/03081070310001633536.

-Mavi, R. K., Zarbakhshnia , N. & Khazraei, A. (2018). Bus rapid transit (BRT): A simulation and multi criteria decision making (MCDM) approach. Transport Policy, 72, 187-197.doi.org/10.1016/j.tranpol.2018.03.010.

-Mirzahossein, H., & Zargari, S. A. (2018). A Combined Model of Congestion Toll Pricing Based on System Optimization with Minimum Toll. Tehnički vjesnik, 25(4), 1162-1168.doi.org/10.17559/TV-20160528093317.

-Habibi, H. M., Mirzahossein, H., & Afandizadeh, S. (2021). Hybrid approach of technical requirements prioritizing to meet road high-demand public transportation needs under uncertainty conditions: A case study of Arba'een trips. Case Studies on Transport Policy. In press. doi.org/10.1016/j.cstp.2021.03.006.

-Raiffa, H., & Keeney, R. L. (1975). Decision Analysis with Multiple Conflicting Objectives, Preferences and Value Tradeoffs. IIASA Working Paper. IIASA, Laxenburg, Austria: WP-75-053. http://pure.iiasa.ac.at/375.

-Pakdil, F., & Kurtulmuşoğlu, F. B. (2014). Improving service quality in highway passenger transportation: a case study using quality function deployment. European Journal of Transport and Infrastructure Research, 14(4), 375-393. ISSN: 1567-7141. doi:10.18757/ejtir.2014.14.4.3043.

-Pandey, M. M. (2020). Evaluating the strategic design parameters of airports in Thailand to meet service expectations of Low-Cost Airlines using the Fuzzy-based QFD method. Journal of Air Transport Management, 82, 101738. doi.org/10.1016/j.jairtraman.2019.101738.

-Srivastava, R. P. (2011). An introduction to evidential reasoning for decision making under uncertainty: Bayesian and belief function perspectives. International Journal of Accounting Information Systems, 12(2), 126-135.doi.org/10.1016/j.accinf.2010.12.003.

-Suman, H. K., Bolia, N. B., & Tiwari, G. (2017). Comparing public bus transport service attributes in Delhi and Mumbai: Policy implications for improving bus services in Delhi. Transport Policy, 56, 63-74.doi.org/10.1016/j.tranpol.2017.03.002.

-Wang, R. T. (2007). Improving service quality using quality function deployment: The air cargo sector of China airlines. Journal of Air Transport Management, 13(4), 221-228. doi.org/10.1016/j.jairtraman.2007.03.005.
-www.rmto.ir

-Yang, J. B., & Singh, M. G. (1994). An evidential reasoning approach for multiple-attribute decision making with uncertainty. IEEE Transactions on systems, Man, and Cybernetics, 24(1), 1-18.doi: 10.1109/21.259681.

-Yamamoto, C., Kishi, K., Hara, F & Satoh, K. (2005). Using Quality Function Deployment To Evaluate Government Services From The Customer's Perspective. Journal of the Eastern Asia Society for Transportation Studies, Vol. 6, pp. 4160 - 4175, 2005. doi:10.11175/easts.6.4160.

-Zhao, Q., Wang, S., Wang, K., & Huang, B. (2019). Multi-objective optimal allocation of distributed generations under uncertainty based on DS evidence theory and affine arithmetic. International Journal of Electrical Power & Energy Systems, 112, 70-82. doi.org/10.1016/j.ijepes.2019.04.044.