A Framework for Assessing Trust in E-government Services under Uncertain Environment

Purpose: In this study, a novel framework was proposed to assess the trust in e-government (e-Gov) services under an uncertain environment. The proposed framework was applied in Iranian municipality websites of e-Gov services to evaluate the readiness score of trust in e-Gov services.

Design/Methodology/Approach: A unique hybrid research methodology was proposed. In the first phase, a comprehensive set of indices were determined from an extensive literature review and finalized by employing the fuzzy Delphi method. In the second phase, Interval-Valued Intuitionistic Fuzzy Sets (IVIFS) was utilized to model the problem's uncertainty with Analytic called IVIFS- Hierarchy Process (AHP) to determine the importance of indices and indicators by assigning the weights. In the third phase, the Fuzzy Evaluation Method (FEM) is followed for assessing the readiness score of indices in case studies.

Finding: The findings indicated that "Trust in government" is the most significant index affecting citizen's trust in e-Gov services while "Maintenance and support" has the least impact on user's intention to use e–Gov services.

Originality: The study is one of the few to indicate significant indices of trust in e-Gov services in developing countries. The study shows the importance of indicators and indices by assigning a weight. Additionally, the framework can assess the readiness score of various case studies.

Research Implications: The study contributes by introducing a unique research methodology that integrates three phases, including Fuzzy Delphi, IVIFS AHP and Fuzzy Evaluation method. Moreover, the Fuzzy sets theory helps to reach a more accurate result by modeling the inherent ambiguity of indicators and indices. Interval-Valued Intuitionistic Fuzzy models the ambiguity of experts' judgments in an interval.

Practical Implications: The study helps policy makers to monitor wider aspects of trust in e-Gov services as well as understanding their importance. The study enables policy makers to apply the framework to any potential case studies to evaluate the readiness score of indices and recognizing strengths and weakness of trust dimensions as well as recommending advice for improving the situation.

***Keywords*:** Trust, e-Gov, MCDM, Interval-valued intuitionistic Fuzzy Sets, Fuzzy evaluation method

1. Introduction

Accelerating expansion of Information and Communication Technology (ICT) leads to a massive transformation in communication between people and organizations in the World. The conventional communication method has replaced with online communication where people can experience fast and easy communication (Kumar et al., 2020; Abdel-Basset et al., 2018; Verkijika and De Wet, 2018 a).

Government agencies are in the quest for better paths to provide enhanced and improved services to citizens (Santa et al., 2019). State and private agencies have seized the opportunity to reap the benefits by delivering online services on the internet aimed at facilitating the use of services by citizens (Twizeyimana and Andersson, 2019). State agencies have done their best to apply cutting-edge technologies and deliver online services to citizens. Such a phenomenon created a new concept as Electronic Government or simply E-Gov (Twizeyimana and Andersson, 2019; Mansoori et al., 2018). E-Gov is delineated as an application of ICT, especially the internet to provide online services to citizens (Joshi and Islam, 2018).

Despite all efforts and inherent advantages of applying e-Gov services, such as making a cutback in organizational cost and providing better quality services to citizens, the adoption of e-Gov services has been taking place at a lower speed (Santa et al., 2019). The United Nations (UN) report showed that despite the high development of e-Gov infrastructure in countries, Citizen's involvement is below the par and people do not have the willingness to use e-Gov services in their daily life (United Nations, 2018). Such prolonging problem has encouraged many researchers and research institutes to conduct different studies to spot existed challenges and barriers of e-Gov adoption (Khan et al., 2019; Santa et al., 2019; Alomari et al., 2012).

Previous studies have reported that the successful adoption of e-Gov is associated with trust in ICT applications and e-Gov (Mensah and Adams, 2019; Santa et al., 2019; Alzahrani et al., 2017, 2018). Mensah et al. (2021) proved that trust is the main significant predictor of user's intention to use e-Gov services. Kamarudin et al. (2021) considered trust as the most important factor in encouraging people to continue to use e-Gov services in developing countries. Therefore, Trust in e-Gov services is an important factor in e-Gov adoption, which has been investigated by a few studies (Alzahrani et al., 2017, 2018) while the studies considered limited aspects of trust within e-Gov services (Santa et al, 2019; Alzahrani et al, 2017, 2018; Xie et al., 2017). For instance, Mensah et al. (2021) have only considered trust in government, information quality and

accessibility as the main indicators. Nofal et al. (2021) assessed the limited number of factors including ease of use, usefulness and trust in government for assessing the role of trust in e-Gov adoption. Following the above explanation, the first research gap is:

1) Each study considered restricted dimensions of trust in e-Gov services, which led to less accuracy in the assessment and final results.

The most common research methodology for assessing the impact of trust in e-Gov adoption is statistical modeling. For instance, Mensah et al. (2021) applied Structural Equation Modeling (SEM) to assess the significant role of trust in e-Gov adoption. Magboul et al. (2021) used SEM in order to assess the role of trust in e-Gov implementation. Trust is a subjective concept and its relevant indicators contain a high level of uncertainty (Lolli et al., 2016). Thus, statistical modelings are unable to capture the inherent vagueness. Another research gap is:

2) Absence of appropriate research methodology to consider the inherent indicators' ambiguity to make the modeling more realistic.

The development of e-Gov services is different in countries. Overdeveloped countries have experienced more maturity in developing e-Gov services while developing countries are still working on improving the services (United Nations, 2018). The assessment of e-Gov is a context-based problem and designing a model for a specific territory cannot be extended for other countries (Munyoka, 2020). For instance, Alarabiat et al. (2021) assessed the role of trust in people's intention to use e-Gov services. The model was designed for Jordanian e-Gov. Munyoka (2020) has designed a framework for assessing the impact of trust on e-Gov implementation. The study was conducted for Zimbabwe e-Gov services. Another research gap is:

3) Each study has been conducted in a specific country and region but no studies have been conducted for evaluating trust in e-Gov services in the Islamic Republic of Iran. Based on the existing literature gaps, the research questions of the paper are:

RQ1: What are the chief indices and indicators for assessing wider aspects of trust in e-Gov services?

RQ2: What is the importance and priority of indices and indicators of trust in e-Gov services for the context of the Islamic Republic of Iran?

RQ3: What will be a robust framework of indices and indicators for assessing wider aspects of trust in e-Gov services for enhancing citizen's trust for increasing people's involvement?

To address the above-mentioned questions, the paper's objectives are:

1. To identify the key indices and indicators for assessing wider aspects of trust in e-Gov services
2. To find the importance and priority of indices and indicators of trust in e-Gov services in the context of the Islamic Republic of Iran
3. To develop a robust framework of indices and indicators to evaluate wider aspects of trust in e-Gov services for enhancing citizen's trust and finally increasing people's involvement.

In this paper, a novel framework was suggested to assess more extensive aspects of trust in e-Gov services as well as applying Fuzzy sets theory for capturing the problem's vagueness. The entire paper is organized as follow: Firstly, different relevant studies were introduced and the key indices and indicators were extracted. In the second section, the extracted indicators were validated by using a Fuzzy Delphi method. In the third step, the IVIFS-AHP method was applied for assigning weight to the indices and indicators. In the third section, the proposed framework was used for evaluating the readiness score of e-Gov services of Tehran municipality. In the next section, the sensitivity analysis was applied to check the framework stability. The next section was allocated for discussion and analyzing the final results.

2. Literature Review

In this section, the current studies on e-Gov and trust in e-Gov are discussed. The relevant studies of trust in e-Gov were recognized and the most important indices and indicators for evaluating trust in e-Gov services were determined, categorized and explained.

2.1. e-Government

E-government (e-Gov) is taken into account as the subset of e-governance which allows public stakeholders to reach information and delivered services (Santa et al., 2019). E-Gov is seen as a great tool for improving citizens and government interaction as well as enhancing responsibility, effectiveness and efficiency (Mensah and Adams, 2019; Santa et al., 2019; Kamoun and Almourad, 2014). E-Gov is a chief strategy that intends to create value for citizens by providing online information, law regulation and policies (Santa et al., 2019; Verkijika and De Wet, 2018a). Massive domination of the E-Gov concept in different spheres from public administration to Information system caused researchers to have various definitions for E-Gov (Aljazzaf, 2019). E-

Gov is delineated as an interaction between people and government by the application of electronic services. In another definition, e-Gov is delineated as the application of web-based services for giving more improved quality services and information to people (Joshi and Islam, 2018; Huang and Benyoucef, 2014). e-Gov is seen as computerizing all citizens and government agencies data and information on the internet aimed at delivering information and services to stakeholders including citizens, businesses and state agencies (United Nations, 2018).

Due to numerous e-Gov advantages such as rapid and effortless access to information and service and increasing efficiency of government bureaucracy, many government agencies have decided to pay more attentions to this phenomenon (Twizeyimana and Andersson, 2019). E-Gov development could also have a direct impact on the improvement of government internal process. More importantly, e-Gov is considered a powerful platform for increasing democracy in society (Mensah and Adams, 2019; Twizeyimana and Andersson, 2019; Zhao et al., 2012).

2.2. Trust in e-Government

Trust is a complicated concept and there is no single and unique definition for it. Trust has been the subject of many researchers in different spheres such as e-commerce, e-Gov, philosophy and e-business (Mensah and Adams, 2019; Smith, 2010). Trust is so essential in interacting and striking up a long-lasting relationship with others (Smith, 2010). There are different definitions of trust that can be delineated as the inclination to rely on trustees, where trustors do not have sufficient and credible information regarding trustees (Alzahrani et al., 2018). Due to the multidimensional concept of trust, different researchers considered the concept of trust in different studies. Each one considered some aspects that are different from others. This has caused confusion in providing a concrete and well-defined delineation (Mensah and Adams, 2019).

As far as it regards e-Gov, various previous studies have shown the major and important effect of trust on e-Gov adoption (Mensah and Adams, 2019; Pappas et al., 2018; Park and Lee, 2018). Table 1 represents the relevant studies that have assessed the impact of the trust dimension on e-Gov adoption.

Table 1 Trust in e-Gov adoption researches

Sr. No.	Reference	Indices	Case country	Methodology
1	Mensah et al. (2021)	Trust in government, Internet, Information quality, Information accessibility	China	Structural equation modelling (SEM)
2	Hammouri et al. (2021)	Security, Usefulness, Information Technology knowledge, Social influence, trust in government	Jordan	Empirical study
3	Al-Swidi and Enazi (2021)	E-Gov awareness, Trust in government, Social influence	Saudi Arabia	SEM
4	Munyoka (2020)	Level of education, usefulness, e-Gov awareness, privacy, security, trust in government	Zimbabwe	SEM
5	Almaiah and Nasereddin (2020)	Website quality, trust in government, trust of internet	Jordan	SEM
6	Santa et al. (2019)	System quality, service quality, information quality, User satisfaction, trust, operational effectiveness	Saudi Arabia	Exploratory study and hypothesis testing
7	Tsui (2019)	Usefulness, Satisfaction, Trust in e-Gov	Taiwan	Descriptive and correlation analysis
8	Muttaqin and Susanto (2019)	Website content, website design, trust in e-Gov, intention to use	Indonesia	Hypothesis testing
9	Ejdys et al. (2019)	Security, Risk, Trust in e-Gov	Poland	Hypothesis testing
10	Mensah and Adams (2019)	Performance expectancy, effort expectancy, social influence, Facilitating condition	China	Hypothesis testing
11	Aljazzaf (2019)	Usefulness, ease of use, privacy, trust in internet, culture, trust in government, trust in e-Gov, risk	Kuwait	Hypothesis testing
12	Abu-Shanab (2019)	Ease of use, social influence, internet experience, usefulness, information quality, privacy and security	Qatar	Empirical study
13	Antoni et al. (2018)	Government knowledge, information quality, Accurate information, security, characteristic of society, online services,	Indonesia	SEM

		information certainty, information disclosure		
14	Pappas et al. (2018)	Information quality, system quality, service quality, trust of service, trust of government	Norway	Qualitative Comparative Analysis
15	Carter and Liu (2018)	Security, usefulness, enjoyment, trusting in e-Gov services	Australia	Hypothesis testing
16	Alzahrani et al. (2018)	Information quality, system quality, service quality, reputation of government, past experience, privacy, security, performance risk, time risk, disposition to trust, trust in e-Gov, intention to use, satisfaction, gender, age, internet experience	Saudi Arabia	Hypothesis testing
17	Alzahrani et al. (2017)	Technical factors, Government agency, disposition to trust, risk factor, gender, age, internet experience	UK	Systematic literature review
18	Aloud and Ibrahim (2018)	Trust in government, trust in technology, information quality, privacy and security assurance	Saudi Arabia	Statistical methods
19	Xie et al. (2017)	Usefulness, ease of use, risk, disposition to trust, trust toward e-Gov, attitude, subjective norm, behavior control, intention	China	Hypothesis testing
20	Nulhusna et al. (2017)	System quality, information quality, service quality, disposition trust, institutional trust, interpersonal trust, continual use	Nepal	Hypothesis testing
21	Ranaweera (2016)	Usefulness, ease of use. trust in e-Gov, security, privacy, risk, information quality	Sri Lanka	SEM

As shown in Table 1, different studies have been conducted in different countries to determine the effect of trust in citizen's willingness to apply e-Gov through applying statistical methods. Moreover, each study assessed the effect of different indices on user's intentions to use e-Gov. The absence of a comprehensive set of indices and indicators for evaluating the impact of trust in

e-Gov was recognized as a serious gap in the previous studies, which has led to less precise and accurate research results.

Each study has introduced different trust-oriented indices and indicators impacting trust in e-Gov. These were reconsidered and categorized by expert's comments and judgments to provide more comprehensive indices. In the previous studies, researchers have considered different names for the same concept. For instance, system quality and usefulness convey the same concept of usability (Santa et al, 2019; Tsui, 2019) or customer service has the same concept of maintenance and support (Muttaqin and Susanto, 2019) or content is as same as information quality (Muttaqin and Susanto, 2019). After meticulous observation of the indices, a comprehensive set of indices are categorized and introduced, namely: usability, trust in government, security, privacy, service quality, maintenance and support, website design, information quality, citizen's social characteristics. By considering the categorized indices, they can assess wider dimensions of citizen's trust in e-Gov services comparing to previous studies. Figure 1 denotes the number of indices in previous researches.

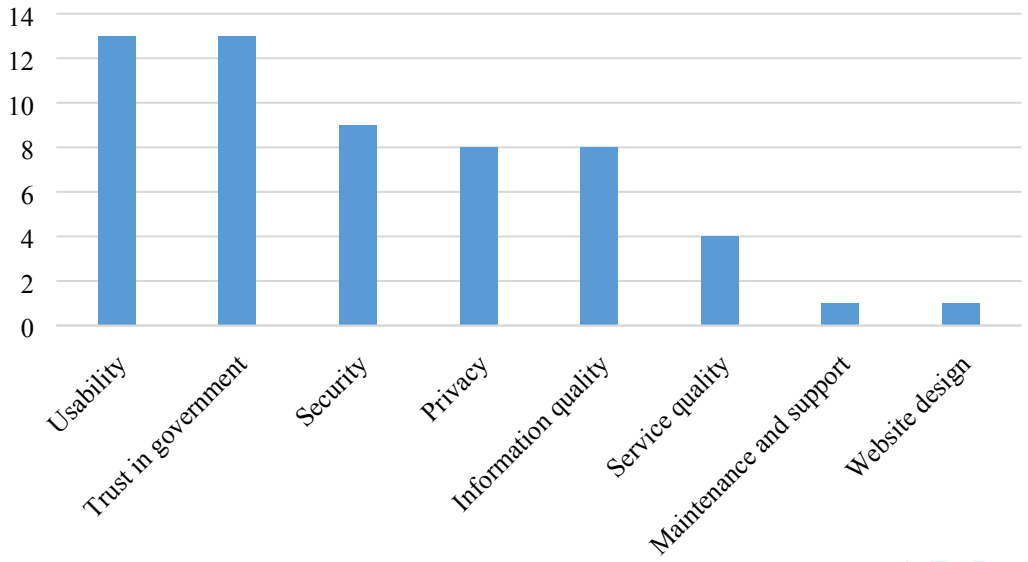

Figure. 1 Number of indices in previous researches

These indicators are categorized into nine indices based on previous studies and expert's judgments (See section 5.1). Table 2 presents the comprehensive set of extracted indices and indicators to evaluate trust in e-Gov:

Table 2 Indices and indicators to evaluate e-Gov

Index	Definition	Indicators	References
Usability	The index assesses needed facilities to facilitate reaching information and services on the websites. The index has mentioned in different studies with different terminology such as usefulness and system quality.	Easy to use e-Gov services Easy to find information and e-services Search engine Simple menu Supporting different foreign languages	Manzoor et al. (2019); Mensah and Adams (2019); Muttaqin and Susanto (2019); Tsui (2019); Ismailova and Kimsanova (2017); Santa et al. (2019)
Trust in government	The index evaluates the extent of citizen's trust in government or state agencies.	Government trustworthy Government honesty in e-services Meeting user's expectations Considering citizen's interest in e-services Government reputation among people	Hamouri et al. (2021); Mensah et al. (2021); Al-Swidi and Enazi (2021); Perez-Morote et al, (2020); Aljazzaf (2019) ; Ejdys et al. (2019); Tsui (2019)
Citizen's social characteristics	The index assesses general social characteristics and trait of vast citizen's in third party and e-services.	Internet knowledge Disposition to trust Citizen's last experience with e-services Social influence	Al-Swidi and Enazi (2021); Munyoka (2020); Saengchai et al. (2020); Aljazzaf (2019); Antoni et al. (2018); Alzahrani et al. (2018); Alzahrani et al. (2017)
Security	The index assesses the presence of a secure and safe platform for data exchange between browser and website's servers with no information leakage	Encrypting data between server and citizen's browser Applying secure protocols including HTTPS and SSL Password for entering user's account Virtual keyboard for entering a password Security code Image	Khan et al. (2021); Aljazzaf (2019); Twizeyimana and Andersson (2019); Antoni et al. (2018); Alzahrani et al. (2018); Verkijika and De Wet (2018 a); Alzahrani et al. (2017)
Privacy	The index assesses government or state agencies' efforts to keep citizen's private information confidential.	Avoiding abusing citizen's personal information Avoiding sharing citizen's information with other organizations Avoiding sharing information with unknown people	Habib et al. (2020); Munyoka (2020); Muttaqin and Susant (2019); Aljazzaf (2019); Abu-Shanab (2019); Alzahrani et al. (2018); Antoni et al. (2018); Alzahrani et al. (2017); Xie et al. (2017); Nulhusna et al. (2017)
Information quality	The index assesses the quality of online presented	Completeness Accuracy	Mensah et al. (2021); Santa et al. (2019);

	information such as accuracy, completeness and precision.	Precision Updating Ease of understanding	Pappas et al. (2018); Antoni et al. (2018); Alzahrani et al. (2018); Nulhusna et al. (2017)
Service quality	The index assesses the reliability, effectiveness and responsiveness of delivered services.	Meeting citizen's requirements Reliable services Effective services Immediate website responsiveness after user's click Applying broad bandwidth between website and server Deploying websites servers inside the country	Mensah et al. (2020); Santa et al. (2019); Pappas et al. (2018); Alzahrani et al. (2018); Verkijika and De Wet (2018 a); Verkijika and De Wet (2018 b)
Maintenance and support	Maintenance and support index is also known as customer service in other studies which evaluates to required facilities to guide and support users during online transactions.	Online supporting services for guiding users Online maintenance services Displaying error message while doing transactions Sending email for informing people about the status of their request Sending tracking number after registration User manual of website	Muttaqin and Susanto (2019); Verkijika and De Wet (2018 a); Benaida et al. (2018); Pena-Lopez (2016)
Website design	The index assesses the website in two aspects of Visual beauty and technical compatibility.	Appealing color Attractive font Simple design Simple and Same web pages design Time, date and weather display Compatibility with different browsers Compatible with different systems (Ex. tablet)	Almaiah and Nasereddin (2020); Manzoor et al. (2019); Muttaqin and Susanto (2019); Tella (2019); Abdel-Basset et al. (2018)

As shown in Table 2, nine indices were introduced by relevant indicators. The indices and indicators were more comprehensive and complete compared to previous studies and can assess wider aspects of trust in e-Gov services.

2.4 Research gaps and problem definition

Assessing citizen's trust in e-Gov is critical and helps decision-makers and authorities to have a better and transparent understanding of citizen's participation and take concrete actions to foster

citizen's trust in e-Gov (United Nations, 2018). As explained in section 2, there are three main gaps in the previous studies:

- Different studies have been carried out to signify the highly important impact of trust on e-Gov adoption (Mensah et al., 2021; Almaiah and Nasereddin (2020); Santa et al, 2019; Tsui, 2019). Each study has tried to highlight the limited aspects of trust associated with the adoption of e-Gov. The studies have proposed new factors impacting on e-Gov adoption which were proven by statistical method (Al-Swidi and Enazi, 2020; Abu-shanab, 2019; Aljazzaf, 2019). The absence of a comprehensive framework to evaluate wider aspects of trust in e-Gov is so highlighted which is seen as the main gap in previous studies. Therefore, the first research question is what are the most chief indices and indicators for a wider assessment of trust in e-Gov?
- Since trust is a subjective concept and there is an overwhelming ambiguity in indices and indicators, applying statistical method cannot model the existed uncertainty inside the concept (Alzahrani et al., 2018; Mensah and Adams, 2019). Previous studies are suffering from applying an appropriate soft computing method to model the problem's uncertainty which is considered as the second most important gap. Thus, the second research question is what research methodology can best model the inherent existed ambiguity of indices and indicators?
- Assessing trust in e-Gov is a context-based problem and conducted in specific countries and regions (Hammouri et al., 2021; Almaiah and Nasereddin, 2020; Munyoka, 2020). Table 1 shows that each study was carried out for different countries. No studies have been conducted for evaluating trust in e-Gov services of the Islamic Republic of Iran. Each study was conducted in a specific country to determine the high significance of trust in the adoption and implementation of e-Gov. The third question is what is the importance and priority of indices and indicators for the context of the Islamic Republic of Iran?

In this research, a novel framework is proposed to cover the existing gap, including the absence of a suitable soft computing method for modelling the existed ambiguity in the problem and assessing the concept in wider aspects by considering a comprehensive set of indices and indicators.

3. Research Methodology

After extracting the most significant indices and indicators, they are supposed to be verified by expert's judgment which was conducted by Fuzzy Delphi. After data verification, the importance of indices and indicators should be determined. Since assessing trust in e-Gov is conducted following different indicators and indices, Multi-Criteria Decision Making (MCDM) methods are the most appropriate approach to determine the priority of indices and indicators (Tooranloo and Iranpour, 2017). Various MCDM methods that have two different applications, including ranking and assigning weight to indicators (Such as Analytical Hierarchy Process and Analytical Network Process) and just providing ranking (such as PROMETHEE, VIKOR and TOPSIS) can be considered (Tooranloo and Iranpour, 2017). Since our study is aiming at assigning weights to the indices and indicators, AHP and ANP methods are the most common MCDM methods.

As there is no dependency between the given indicators and indices, the AHP method is selected for assigning weight to indices and indicators because the method does not consider the dependency between indices and indicators while the ANP method does (Chu et al., 2019). Moreover, the method is so straightforward to use and operates based on the pairwise comparison (Chu et al., 2019).

Trust is a subjective concept and there is a high level of uncertainty and ambiguity within the given indices and indicators, Fuzzy sets theory was applied to model the inherent uncertainty (Lolli et al., 2016). Additionally, due to the absence of experts' agreement on allocating a single membership function for fuzzy numbers for assessing the indices and indicators, Interval-Valued Intuitionistic Fuzzy Sets (IVIFS) numbers were used to get over the problem and model experts' judgments within an Interval [0,1] (Oztaysi et al., 2017). After designing the framework, Fuzzy Evaluation Method was applied to assess the readiness score of indicators and indices by assigning a number.

Figure 2 shows the research methodology process. A novel framework was proposed for assessing trust in e-Gov. The proposed framework process is comprised of three main modules including: a. Extracting and finalizing indices and indicators, b. Assigning weight to indices and indicators and c. Determining indices and indicator readiness score.

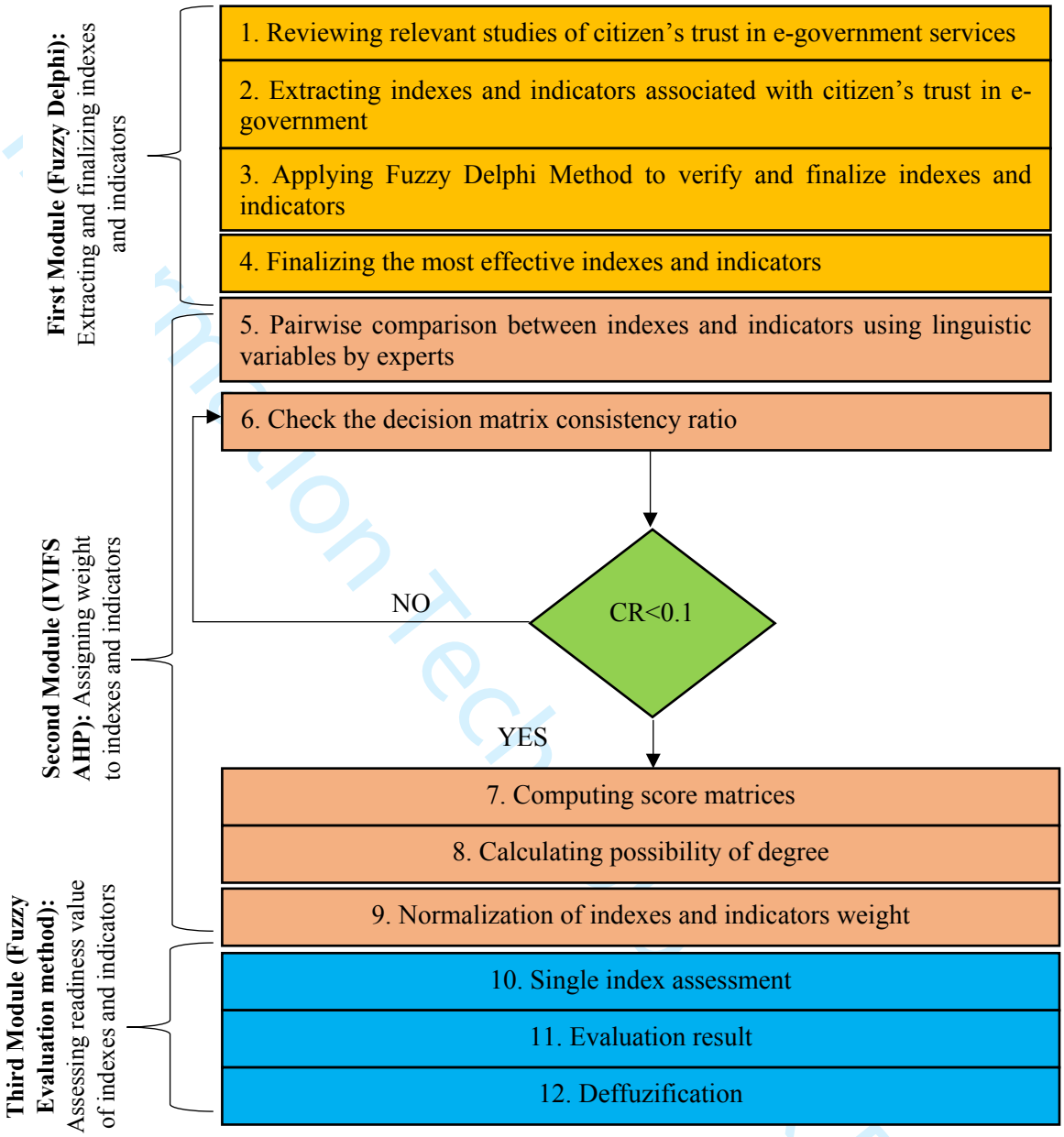

Figure. 2 Proposed research methodology process

3.1. Fuzzy sets theory and Interval-valued intuitionistic fuzzy

Fuzzy sets theory was firstly proposed by Lotfizedeh in 1965 (Ziemba, 2018). The theory is capable of handling the inherent problem's ambiguity (Ziemba, 2018). The theory equips researchers with mathematical tools aimed at capturing existed uncertainty relevant to the human cognitive process. Moreover, the absence of experts' agreement on setting a single membership function for Fuzzy numbers creates a new concept as Internal-Valued Intuitionistic Fuzzy Sets

(IVIFS) which defines Fuzzy number in the interval [0,1]. The most common and useful Fuzzy sets theory and IVIFS definitions are (Tabaraee et al., 2018; Oztaysi et al., 2017):

Definition 1. If $\tilde{A}$ is a fuzzy set, each member is delineated by a membership function $\mu_{\tilde{A}}(x)$ taking a number between zero to one. The greater value shows stronger member belonging to the fuzzy set $\tilde{A}$.

$$\tilde{A} = \{(x, \mu_{\tilde{A}}(x) | x \in X\} \quad (1)$$

Where X is a universal set and $\mu_{\tilde{A}}(x)$: $X \rightarrow [0,1]$

Definition 2. A fuzzy number is a subset of fuzzy set in the universe of discourse X which is normalized and convex. Trapolized $A = (a_1,a_2,a_3,a_4)$ and triangular $B = (a_1,a_2,a_3)$ are the most common use fuzzy numbers whose membership functions are defined by:

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x - a_1}{a_2 - a_1}, & m_1 \leq x \leq m_2 \\ 1, & m_1 \leq x \leq m_2 \\ \frac{a_4 - x}{a_4 - a_3}, & m_1 \leq x \leq m_2 \\ 0, & otherwise \end{cases} \quad (2)$$

$$\mu_x(A) = \begin{cases} \frac{x - a_1}{a_2 - a_1} & if\ a_1 \leq x \leq a_2 \\ \frac{a_3 - x}{a_3 - a_2} & if\ a_2 \leq x \leq a_3 \\ 0 & \text{Other} \end{cases} \quad (3)$$

Definition 4. The most common arithmetic operations on triangular fuzzy numbers $A = (a_1,a_2,a_3)$ and $B = (b_1,b_2,b_3)$ are given in Table 3.

Table 3 Arithmetic operations

No	Operation	Result
1	Addition	$A + B = (a_1 \square a_2 \square a_3) + (b_1 \square b_2 \square b_3) = (a_1 + b_1 \square a_2 + b_2 \square a_3 + b_3)$
2	Subtraction	$A - B = (a_1 \square a_2 \square a_3) - (b_1 \square b_2 \square b_3) = (a_1 - b_2 \square a_2 - b_2 \square a_3 - b_1)$
3	Multiplication	$A \times B = (a_1 \square a_2 \square a_3) \times (b_1 \square b_2 \square b_3) = (a_1 \times b_1 \square a_2 \times b_2 \square a_3 \times b_3)$
4	Positive crisp number (k) Multiplication into fuzzy number	$k \times (a \square a_2 \square a_3) = (k \times a_1 \square k \times a_2 \square k \times a_3) \quad if\ k > 0$
5	Negative crisp number (k) Multiplication into fuzzy number	$k \times (a \square a_2 \square a_3) = (k \times a_3 \square k \times a_2 \square k \times a_1) \quad if\ k < 0$

Definition 5. Fuzzy triangular number $\tilde{A} = (a_1, a_2, a_3)$ is deffuzified by:

$$Deff(\tilde{A}) = \frac{a_1 + a_2 + a_3}{3} \quad (4)$$

Definition 6. Interval-Valued Intuitionistic Fuzzy Set (IVIFS) $\tilde{A}$ in universal set X is defined by:

$$\tilde{A} = \{\langle x, [\mu_{\tilde{A}}^{-}, \mu_{\tilde{A}}^{+}], [\upsilon_{\tilde{A}}^{-}, \upsilon_{\tilde{A}}^{+}] \rangle; x \in X\} \quad (5)$$

Where $0 \leq \mu_{\tilde{A}}^{-}, \mu_{\tilde{A}}^{+} \leq 1$ for all $x \in X$. $\mu_{\tilde{A}}^{-}$ and $\mu_{\tilde{A}}^{+}$ are lower and upper membership functions respectively. $\upsilon_{\tilde{A}}^{-}$ and $\upsilon_{\tilde{A}}^{+}$ denote lower and upper non-membership functions respectively.

Definition 7. If $\tilde{A} = ([\mu_{\tilde{A}}^{-}, \mu_{\tilde{A}}^{+}], [\upsilon_{\tilde{A}}^{-}, \upsilon_{\tilde{A}}^{+}])$ and $\tilde{B} = ([\mu_{\tilde{B}}^{-}, \mu_{\tilde{B}}^{+}], [\upsilon_{\tilde{B}}^{-}, \upsilon_{\tilde{B}}^{+}])$ are two IVIFS numbers, the arithmetic operations are provided in Table 4.

Table 4. Arithmetic operations on IVIFS numbers

Operation	Result
Addition	$\tilde{A} \oplus \tilde{B} = [\mu_{\tilde{A}}^{-} + \mu_{\tilde{B}}^{-} - \mu_{\tilde{A}}^{-}\mu_{\tilde{B}}^{-}, \mu_{\tilde{A}}^{+} + \mu_{\tilde{B}}^{+} - \mu_{\tilde{A}}^{+}\mu_{\tilde{B}}^{+}], [\upsilon_{\tilde{A}}^{-}\upsilon_{\tilde{B}}^{-}, \upsilon_{\tilde{A}}^{+}\upsilon_{B}^{+}]$
Multiplication	$\tilde{A} \otimes \tilde{B} = [\mu_{\tilde{A}}^{-}\mu_{\tilde{B}}^{-}, \mu_{\tilde{A}}^{+}\mu_{\tilde{B}}^{+}], [\upsilon_{\tilde{A}}^{-} + \upsilon_{\tilde{B}}^{-} - \upsilon_{\tilde{A}}^{-}\upsilon_{\tilde{B}}^{-}, \upsilon_{\tilde{A}}^{+} + \upsilon_{\tilde{B}}^{+} - \upsilon_{\tilde{A}}^{+}\upsilon_{\tilde{B}}^{+}]$
Multiplication of a crisp number ƛ into IVIFS number $\tilde{A}$	$\lambda\tilde{A} = [1 - (1 - \mu_{\tilde{A}}^{-})^{\lambda}, 1 - (1 - \mu_{\tilde{A}}^{+})^{\lambda}], [(\upsilon_{\tilde{A}}^{-})^{\lambda}, (\upsilon_{\tilde{A}}^{+})^{\lambda}]$, ƛ>0
IVIFS number to the power of ƛ	$\tilde{A}^{\lambda} = [(\mu_{\tilde{A}}^{-})^{\lambda}, (\mu_{\tilde{A}}^{+})^{\lambda}], [1 - (1 - \upsilon_{\tilde{A}}^{-})^{\lambda}, 1 - (1 - \upsilon_{\tilde{A}}^{+})^{\lambda}]$, ƛ>0

Definition 8. If $\tilde{r}_{ij}^{k} = ([\mu_{\tilde{r}}^{-}, \mu_{\tilde{r}}^{+}], [\upsilon_{\tilde{r}}^{-}, \upsilon_{\tilde{r}}^{+}])$ is an IVIFS number where $k = 1, 2, \ldots, n$. the aggregated IVIFS number is calculated by:

$$r_{ij}^{A} = \left\langle [\prod_{k=1}^{n}(\mu_k^{-})^{w_k}, \prod_{k=1}^{n}(\mu_k^{+})^{w_k}], \left[1 - \prod_{k=1}^{n}(1 - \upsilon_k^{-})^{w_k}, 1 - \prod_{k=1}^{n}(1 - \upsilon_k^{+})^{w_k}\right] \right\rangle \quad (6)$$

Where w_k is the weight vector of each respondent and $\sum_{k=1}^{n} w_k = 1$.

Definition 9. IVIFS number $\tilde{A} = ([\mu_{\tilde{A}}^{-}, \mu_{\tilde{A}}^{+}], [\upsilon_{\tilde{A}}^{-}, \upsilon_{\tilde{A}}^{+}])$ is deffuzified D by:

$$D(\tilde{A}) = \frac{\mu_{\tilde{A}}^{-} + \mu_{\tilde{A}}^{+} + (1 - \upsilon_{\tilde{A}}^{-}) + (1 - \upsilon_{\tilde{A}}^{+}) + \mu_{\tilde{A}}^{-}\mu_{\tilde{A}}^{+} - \sqrt{(1 - \upsilon_{\tilde{A}}^{-}) \times (1 - \upsilon_{\tilde{A}}^{+})}}{4} \quad (7)$$

3.2. Fuzzy Delphi

Delphi method was firstly introduced by RAND Corporation. The method is used for collecting distributed expert's judgments on cross-disciplinary topics (Zhang and Lam, 2019). Delphi is a qualitative technique that can determine the significance of indices and indicators. The decision-

making process is based on human thinking and judgments which are inundated with uncertainty and vagueness (Zhang and Lam, 2019). Therefore, the fuzzy sets theory was introduced by Ishikawa to capture existed ambiguity associated with indices and indicators (Singh and Sarkar, 2020). Fuzzy Delphi is used for verifying the extracted indices and indicators presented in Table 2 by expert's judgments. The fuzzy Delphi method is comprised of the following steps (Singh and Sarkar, 2020; Zhang and Lam, 2019):

a. Indicators extraction: Firstly, a meticulous and precise literature review is conducted aimed at eliciting the most frequent and applied indicators from previous studies. Table 2 shows the most frequent indicators for assessing people's trust in e-Gov.

b. Collecting expert's judgments: In the next step, a 5 scale-Likert questionnaire was designed to be distributed among a limited number of experts in the field of e-Gov and Information Technology (IT) to raise their comments regarding the importance of indicators. Each expert selected a linguistic variable, presented in Table 5, to determine the importance of indicators.

Table 5 Converting linguistic variables into fuzzy triangular number

Linguistic Variables	Fuzzy triangular fuzzy number
Extremely unimportant	(0.1,0.1,0.3)
Unimportant	(0.1,0.3,0.5)
Normal	(0.3,0.5,0.7)
Important	(0.5,0.7,0.9)
Extremely important	(0.7,0.9,0.9)

c. Converting linguistic variable: After collection of expert's judgments, linguistic variables were turned into fuzzy numbers $\tilde{A}_{ij} = (a_{ij},b_{ij},c_{ij})$ based on conversion Table 5:

$$\tilde{A}_{ij} = (a_{ij},b_{ij},c_{ij}), i = 1,2,\ldots, n \ \& \ j = 1,2,3,\ldots m \quad (8)$$

Where a_{ij} shows ith index importance of jth expert. n denotes the number of indices or indicators and m denotes the number of experts.

d. Data Aggregation: Since the number of experts for determining the importance of indicators exceeds one person, data aggregation is done for determining the fuzzy weight of ith index: $\tilde{A} = (a_i, b_i, c_i)$ by:

$$a_i = min\,(a_{ij})\,,\ b_i = \prod_{j=1}^{m} b_{ij}\,,\ c_i = max\,(c_{ij}) \quad (9)$$

e. Deffuzification: In the last step, the aggregated fuzzy triangular number is deffuzified by:

$$D_i = \frac{a_i + b_i + c_i}{3},\ i = 1,2,3,\ldots,n \quad (10)$$

The deffuzification score is compared to a threshold(θ). If the score is more than the threshold (θ) then it is kept as an assessment indicator otherwise it is removed from the assessment list. Setting the value of the threshold is calculated based on the average minimum value of the important linguistic variable (0.5) and maximum value of the normal (0.7) linguistic variable, which results in 0.6 (Noori et al., 2020; Kumar et al., 2018).

3.3. IVIFS AHP

The Analytical Hierarchy Process method was firstly introduced by Saaty in 1970 (Dogan et al., 2019). The method can change sophisticated decision-making problems into easy pairwise comparison. The easy to use and high accuracy characteristics in assigning weights to criteria and ranking alternatives have attracted researchers to employ this method (Tooranloo and Iranpour, 2017). The method was used to assign a weight to the verified indices and indicators. Due to inherent ambiguity in the indices and indicators, the fuzzy sets theory was used to model the uncertainty, moreover, the absence of experts' agreements on setting a membership function for fuzzy numbers, Interval-valued intuitionistic numbers were used (Dogan et al., 2019; Tooranloo and Iranpour, 2017). IVIFS AHP method steps are explained as (Dogan et al., 2019; Tooranloo and Iranpour, 2017) as:

Step 1. Pairwise Comparison: Indices and relevant indicators are compared pair wisely by expert's judgments. All expert fill the decision matrix with linguistic variables presented in Table 6.

Table 6 Converting linguistic variables into IVIFS number

Linguistic variables	IVIFS Number
Absolutely low	([0.1,0.25]), ([0.65,0.75)]
Very low	([0.15,0.3]), ([0.6,0.7)]
Low	([0.2,0.35]), ([0.55,0.65)]
Medium low	([0.25,0.4]), ([0.5,0.6)]
Approximately equal	([0.45,0.55]), ([0.3,0.45)]
Exactly equal	([0.5,0.5]), ([0.5,0.5)]
Medium high	([0.5,0.6]), ([0.25,0.4)]
High	([0.55,0.65]), ([0.2,0.35)]
Very high	([0.6,0.7]), ([0.15,0.0.3)]
Absolutely High	([0.65,0.75]), ([0.1,0.25)]

Step 2. Converting linguistic variables: Linguistic variables are converted to IVIFS numbers based on Table 6.

Step 3. Data aggregation: Expert's judgments are supposed to be aggregated by:

$$r_{ij} = \left(\left[1 - \prod_{k=1}^{h}(1-\mu_{ijk}^{-})^{q_k}, 1 - \prod_{k=1}^{h}(1-\mu_{ijk}^{+})^{q_k}\right], \left[\prod_{k=1}^{h}(\upsilon_{ijk}^{-})^{q_k}, \prod_{k=1}^{h}(\upsilon_{ijk}^{+})^{q_k}\right]\right) \quad (11)$$

Where μ_{ijk}^{-} and μ_{ijk}^{+} denote the lower and upper membership function of ith and jth indices comparison in decision matrix respectively conducted by kth expert. υ_{ijk}^{-} and υ_{ijk}^{+} show the lower and upper non-membership function of ith and jth indices comparison in decision matrix respectively which are carried out by kth expert. H refers to the number of experts. $q_k$refers to the expert weight whose addition is equal to one $\sum_{k=1}^{h} q_k = 1$. If experts have the same weight the equation reduces to:

$$r_{ij} = \left(\left[1 - \prod_{k=1}^{h}(1-\mu_{ijk}^{-})^{\frac{1}{h}}, 1 - \prod_{k=1}^{h}(1-\mu_{ijk}^{+})^{\frac{1}{h}}\right], \left[\prod_{k=1}^{h}(\upsilon_{ijk}^{-})^{\frac{1}{h}}, \prod_{k=1}^{h}(\upsilon_{ijk}^{+})^{\frac{1}{h}}\right]\right) \quad (12)$$

$$\tilde{R}_g = \begin{bmatrix} ([\mu_{11}^{-},\mu_{11}^{+}],[\upsilon_{11}^{-},\upsilon_{11}^{+}]) & \cdots & ([\mu_{1n}^{-},\mu_{1n}^{+}],[\upsilon_{1n}^{-},\upsilon_{1n}^{+}]) \\ \vdots & \ddots & \vdots \\ ([\mu_{n1}^{-},\mu_{n1}^{+}],[\upsilon_{n1}^{-},\upsilon_{n1}^{+}]) & \cdots & ([\mu_{nn}^{-},\mu_{nn}^{+}],[\upsilon_{nn}^{-},\upsilon_{nn}^{+}]) \end{bmatrix} \quad (13)$$

Step 4. Score Matrices: The score matrices $(\tilde{S})$ are created by applying a score function:

$$\tilde{S} = \begin{bmatrix} ([\mu_{11}^{-} - \upsilon_{11}^{+}],[\mu_{11}^{+} - \upsilon_{11}^{-}]) & \cdots & ([\mu_{1n}^{-} - \upsilon_{1n}^{+}],[\mu_{1n}^{+} - \upsilon_{1n}^{-}]) \\ \vdots & \ddots & \vdots \\ ([\mu_{n1}^{-} - \upsilon_{n1}^{+}],[\mu_{n1}^{+} - \upsilon_{n1}^{-}]) & \cdots & ([\mu_{nn}^{-},\upsilon_{nn}^{+}],[\mu_{nn}^{+} - \upsilon_{nn}^{-}]) \end{bmatrix} \quad (14)$$

Step 5. Interval exponential: Interval exponential matrices are obtained by:

$$\tilde{A} = \begin{bmatrix} e^{([\mu_{11}^{-} - \upsilon_{11}^{+}],[\mu_{11}^{+} - \upsilon_{11}^{-}])} & \cdots & e^{([\mu_{1n}^{-} - \upsilon_{1n}^{+}],[\mu_{1n}^{+} - \upsilon_{1n}^{-}])} \\ \vdots & \ddots & \vdots \\ e^{([\mu_{n1}^{-} - \upsilon_{n1}^{+}],[\mu_{n1}^{+} - \upsilon_{n1}^{-}])} & \cdots & e^{([\mu_{nm}^{-},\upsilon_{nm}^{+}],[\mu_{nm}^{+} - \upsilon_{nm}^{-}])} \end{bmatrix} = \begin{bmatrix} [\alpha_{11}^{-},\alpha_{11}^{+}] & \cdots & [\alpha_{1n}^{-},\alpha_{1n}^{+}] \\ \vdots & \ddots & \vdots \\ [\alpha_{n1}^{-},\alpha_{n1}^{+}] & \cdots & [\alpha_{nn}^{-},\alpha_{nn}^{+}] \end{bmatrix} \quad (15)$$

Step 6. Priority vector: The priority vector of internal exponential matrices is obtained by:

$$w_i = \left[\frac{\sum_{j=1}^{n}\alpha_{ij}^{-}}{\sum_{i=1}^{n}\sum_{j=1}^{n}\alpha_{ij}^{+}}, \frac{\sum_{j=1}^{n}\alpha_{ij}^{+}}{\sum_{i=1}^{n}\sum_{j=1}^{n}\alpha_{ij}^{-}}\right] = [w_i^{-}, w_i^{+}], i = 1,2,3,\ldots,n \quad (16)$$

Step 6. Possibility of Degree Matrices: The possibility degree of matrices is calculated by:

$$p(w_i > w_j) = p_{ij} = \frac{max\,(0, w_i^{+} - w_j^{-}) - max(0, w_i^{-} - w_j^{+})}{(w_i^{+} - w_i^{-}) + (w_j^{+} - w_j^{-})} \quad (17)$$

Step 7. Weight calculation: The weight value of indices and indicators is obtained by:

$$w_i = \frac{\sum_{j=1}^{n} p_{ij} - 1}{n} + 0.5 \quad (18)$$

Step 8. Normalization: In the last step, the index's weight is normalized by:

$$w_i^T = \frac{w_i}{\sum_{i=1}^{n} w_i} \tag{19}$$

3.4. Fuzzy Evaluation Method

The fuzzy evaluation method uses fuzzy mathematic theories, arithmetic fuzzy operations and maximum membership degree fundamental to assess indicators and indices by assigning a score (Guo and Li, 2019; Ramanayaka et al., 2019). The method is applied in two layers for assessing indices and indicators. The method is made of the following steps (Ramanayaka et al., 2019):

Step 1. Indices and indicators recognition: In the first step, the most important indices and indicators are recognized and extracted.

Step 2. Assessors: In this step, a handful of assessors is chosen for evaluating the indicators. The assessors do not need to be experts because the indicators stem from a general concept and are easy to understand by general users.

Step 3. Questionnaire: A declarative questionnaire was created based on five verbal scales of Excellent, very good, good, fair and poor then assessor's response is assigned a numeric value for turning the qualitative data into quantitative ones as: $V = (100,80,60,40,25)$. The number of assessors is shown by $E = \{E_1,E_2,...,E_m\}$. m refers to the number of assessors.

Step 4. Single index assessment: Each index is assessed by relevant indicators independently which is written by fuzzy vector $R_i = (r_{i1}, r_{i2},..., r_{im}), i = 1,2,...n, R_i \in \mu(V)$. m refers to the number of comments set. The evaluation vector has a normalized condition where $r_{i1} + r_{i2} +... + r_{im} = 1$. Since each index is made of different indicators therefore all indicators evaluation is a fuzzy relationship R from D to V:

$$R = (r_{pq})_{n \times m} = \begin{pmatrix} r_{11} & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nm} \end{pmatrix} \tag{20}$$

Where r_{pq} shows the grade of membership of indicators D_i for the comment v_j. n denotes the number of indicators relevant to the index D_i.

Step 5. Evaluation result: the evaluation result is computed by multiplication of index weight vector into matrix R of assessment index:

$$B = W.R = (b_1,b_2,...,b_m) = (w_1,w_2,...,w_t)\begin{bmatrix} r_{11} & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{t1} & \cdots & r_{tm} \end{bmatrix} = (\sum_{i=1}^{t}(w_i * w_{i1}),\sum_{i=1}^{t}(w_i * w_{i2}),..., \sum_{i=1}^{t}(w_i * w_{im})$$

(21)

B shows the assessment result of index $D_k$associated with kth element in the comment set.

Step 6. Deffuzification: The fuzzy score of indices and indicators are deffuzified by:

$$a = \frac{\sum_{i=1}^{m} b_i^2 v_i}{\sum_{i=1}^{m} b_i^2} \quad (22)$$

Where $b_i$is an assessment vector. v_i is comment value.

4. Proposed research methodology framework

As shown in Figure 2, the research methodology process is comprised of three main modules, including finalizing indices and indicators by using fuzzy Delphi" then the validated indicators and indices are assigned weight using IVIFS AHP method and finally the framework is applied for different case studies aiming at assessing the readiness score of trust in e-Gov services using "Fuzzy Evaluation Method".

4.1. Finalizing indices and indicators using Fuzzy Delphi

In this step, all relevant studies of citizen's trust in e-Gov were reviewed and the most frequent indices and indicators were elicited shown in Table 2. After collecting the indices and indicators, the Fuzzy Delphi method was applied to collect the expert's opinion by a Likert scale questionnaire to validate the indices and indicators. After collecting the expert's judgments, the indicators score was calculated by equation from 8 to 10. If the score is higher than 0.6 (Noori et al., 2020; Kumar et al., 2018), the indicators are accepted otherwise they are omitted. Table 7 shows the final verified indicators:

Table 7 Finalization of the indices

Indicators	Response Score
Easy to use e-Gov services	0.62
Easy to find information and e-services	0.75
Search engine	0.81
Simple menu	0.64
Supporting different foreign languages	0.28
Government trustworthy	0.68
Government honesty in e-services	0.65

Meeting user's expectations	0.51
Considering citizen's interest in e-services	0.67
Government reputation among people	0.80
Internet knowledge	0.63
Disposition to trust	0.71
Citizen's last experience with e-services	0.69
Social influence	0.82
Encrypting Data between server and citizen's browser	0.75
Applying secure protocols including HTTPS and SSL	0.53
Password for entering user's account	0.66
Virtual keyboard for entering password	0.79
Security code Image	0.65
Avoiding abusing citizen's personal information	0.76
Avoiding sharing citizen's information with other organizations	0.36
Avoiding sharing information with unknown people	0.68
Completeness	0.79
Accuracy	0.82
Precision	0.81
Updating	0.78
Ease of understanding	0.79
Meeting citizen's requirements	0.62
Reliable services	0.81
Effective services	0.80
Immediate website responsiveness after user's click	0.63
Applying broad bandwidth between website and server	0.28
Deploying websites servers inside the country	0.69
Online supporting services for guiding users	0.74
Online maintenance services	0.66
Displaying error message display while doing transactions	0.68
Sending email for informing users about the status of their request	0.63
Sending tracking number after registration	0.79
User manual of website	0.62
Appealing color	0.81
Attractive font	0.65
Simple design	0.62
Simple and Same web pages design	0.61
Time, date and weather display	0.61
Compatibility with different browsers	0.81
Compatible with different systems (Ex. Mobile phone, tablet)	0.79

As it is shown in Table 7, the expert's judgments are deffuzified and the final results were compared to the threshold ($\theta = 0.6$). The vast majority of indicators value exceeded the threshold (More than 0.6) and managed to be considered as the proposed framework indicators. Five indicators whose final results were less than the threshold ($\theta = 0.6$) were omitted, these include "Supporting different foreign languages", "Meeting user's expectations", "Supporting secure protocols such as HTTPS and SSL", "Avoiding sharing citizen's information with other

organizations", "Applying wide bandwidth between website and server". The final verified indicators were grouped based on previous studies and expert's judgments. Table 8 shows the proposed framework indices and indicators.

Table 8 Final verified proposed framework indices and indicators

Index	Indicators
Usability	Easy to use e-Gov services
	Easy to find information and e-services
	Search engine
	Simple menu
Trust in government	Government trustworthy
	Government honesty in e-services
	Considering citizen's interest in e-services
	Government reputation among people
Citizen's social characteristics	Internet knowledge
	Disposition to trust
	Citizen's last experience with e-services
	Social influence
Security	Encrypting data between server and citizen's browser
	Password for entering user's account
	Virtual keyboard for entering a password
	Security code Image
Privacy	Avoiding abusing citizen's personal information
	Avoiding sharing information with unknown people
Information quality	Completeness
	Accuracy
	Precision
	Updating
	Ease of understanding
Service quality	Meeting citizen's requirements
	Reliable services
	Effective services
	Immediate website responsiveness after each click
	Deploying websites servers inside the country
Maintenance and support	Online supporting services for guiding users
	Online maintenance services
	Displaying error message while doing transactions
	Sending email for informing users about the status of their request
	Sending tracking number after registration
	User manual of website
Website design	Appealing color
	Attractive font
	Simple design
	Simple and Same web pages design
	Time, date and weather display
	Compatibility with different browsers
	Compatible with different systems (Ex. tablet)

4.2. Assigning weight to indices and indicators using IVIFS AHP

In this step, the verified indices and indicators were assigned weight using IVIFS AHP, A pairwise-based questionnaire was handed out to 23 experts in the field of e-Gov and information technology, whose demographic information presented in Table 9, to compare indices and indicators pair wisely using linguistic variables shown in Table 6.

Table 9 Demographic information of respondents

Gender	Female	17 persons	74%
	Male	6 persons	16%
	Bachelor	7 persons	30%
Education	Master	11 persons	48%
	PhD	5 persons	22%
	Less than 35 years	5 persons	21%
Age	Between 35 and 45 years	9 persons	39%
	Between 45 and 55 years	5 persons	21%
	More than 55 years	4 persons	19%
Work experience	Less than 8 years	4 persons	17%
	Between 8 and 12 years	12 persons	48%
	More than 12 years	7 persons	35%
	Academic staff	11 persons	48%
Career	Expert	7 persons	30%
	Manager	5 persons	21%

Table 10 and Figure 3 show the final results:

Table 10 The proposed framework

Index	Weight	Rank	Indicators	Weight	Rank
Usability	0.0892	7	Easy to use e-Gov services	0.3913	1
			Easy to find information and e-services	0.3043	2
			Search engine	0.2173	3
			Simple menu	0.0869	4
Trust in government	0.1531	1	Government trustworthy	0.2974	1
			Government honesty in e-services	0.2333	3
			Considering citizen's interest in e-services	0.2187	4
			Government reputation among people	0.2666	2

Citizen's social characteristics	0.132	3	Internet knowledge	0.2413	3
			Disposition to trust	0.2758	2
			Citizen's last experience with e-services	0.1724	4
			Social influence	0.3103	1
Security	0.129	4	Data encryption between server and citizen's browser	0.2909	2
			Password for entering user's account	0.3090	1
			Virtual keyboard for entering password	0.2181	3
			Security code Image	0.1818	4
Privacy	0.1496	2	Avoiding abusing citizen's personal information	0.6234	1
			Avoiding sharing information with unknown people	0.3766	2
Information quality	0.0724	8	Completeness	0.2122	2
			Accuracy	0.1856	4
			Precision	0.1644	5
			Updating	0.2387	1
			Ease of understanding	0.1989	3
Service quality	0.1006	6	Meeting citizen's requirements	0.2272	1
			Reliable services	0.2070	3
			Effective services	0.2222	2
			Immediate website responsiveness after each click	0.1818	4
			Deploying websites servers inside the country	0.1616	5
Maintenance and support	0.0489	9	Online supporting services for guiding users	0.1744	3
			Online maintenance services	0.1395	5
			Displaying error message while doing transactions	0.1162	6
			Sending email for informing users about the status of their request	0.2093	1
			Sending tracking number after registration	0.1627	4
			User manual of website	0.1976	2
Website design	0.1252	5	Appealing color	0.1744	3
			Attractive font	0.1356	4
			Simple design	0.1201	5
			Simple and Same web pages design	0.1143	6
			Time, date and weather display	0.0775	7
			Compatibility with different browsers	0.1841	2
			Compatible with different systems (Ex. Tablet)	0.1937	1

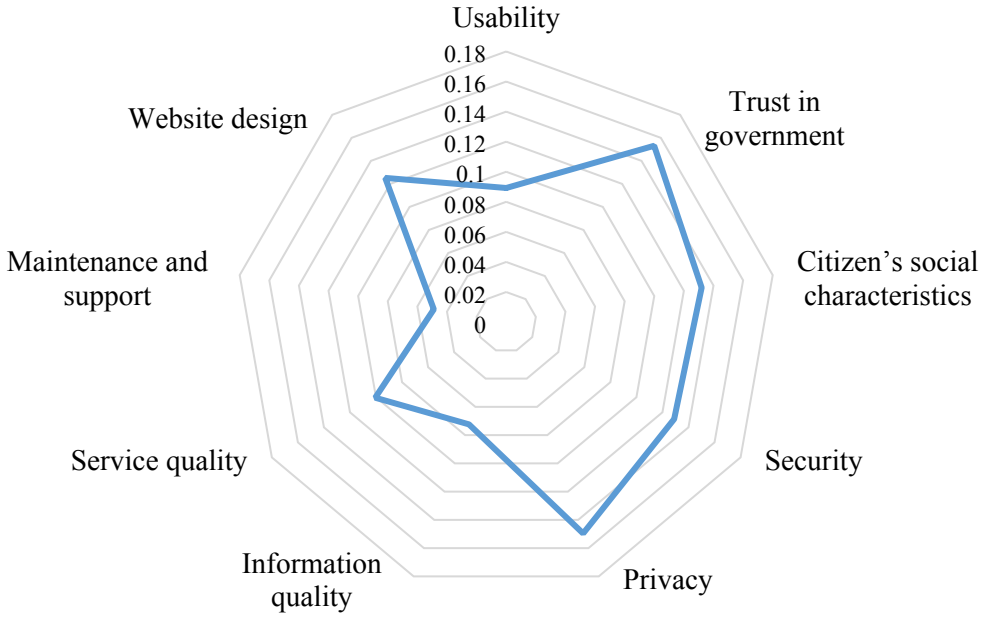

Figure. 3 The proposed framework's indices weight

As shown in Table 10 and Figure 3, the method determined the preference of indices and indicators. The higher weight value denotes the higher importance of indices which are ordered as Trust in government, privacy, citizen's social characteristics, security, website design, service quality, usability, information quality, maintenance and support respectively.

4.3. Readiness Score: Application about E-Gov services of Tehran's municipality website

The readiness score of each index and indicator was computed by Fuzzy Evaluation Method (FEM). Firstly, a questionnaire was distributed between assessors to assign a linguistic variable (Excellent, very good, good, fair, poor) to each indicator then their responses were computed using the equations from 20 To 22. The readiness score of indicators, indices and overall evaluation on the main subject was obtained. The value takes a number from zero to one hundred. The higher value denotes the higher citizen's trust in e-Gov.

A municipality is considered as the lowest level of governance in each country, e-Gov services are delivered by municipalities of each city at the local level. Municipalities are responsible for providing essential infrastructure and services such as health, social care, environment and

management services, public transport, cleaning, waste collection, cultural and sports services as well as enhancing citizen's involvement in local decision making (United Nations, 2018).

Owing to the high significance of e-services quality provided by municipalities, the proposed framework was applied for assessing trust in e-Gov services of the municipality website. The framework assessed trust in e-Gov services of Tehran municipality. The assessment was conducted by 12 Iranian users and were asked to evaluate the website by selecting a linguistic variable (Excellent, very good, good, fair, poor). The user's comments were aggregated and set into a matrix. For instance, the usability index is comprised of 4 indicators and each indicator was assessed by the users. When "easy to use e-Gov services" was considered, 71 percent marked fair, 19 percent marked good, 10 percent marked very good. When easy to find information and e-services were considered, 59 percent of users marked fair, 22 percent marked good and 19 percent marked very good. When search engine is considered, 55 percent marked fair, 27 percent marked good, 8 percent marked very good and 10 percent marked excellent. When simple menu was considered, 42 percent marked fair, 37 percent marked good, 9 percent marked very good and 12 percent marked excellent so the Usability matrix $R_{Usability}$ was created as:

$$R_{Usability} = \begin{bmatrix} 0 & 0.71 & 0.19 & 0.1 & 0 \\ 0 & 0.59 & 0.22 & 0.19 & 0 \\ 0 & 0.55 & 0.27 & 0.08 & 0.1 \\ 0 & 0.42 & 0.37 & 0.09 & 0.12 \end{bmatrix}$$

Similarly, the rest of the indices were calculated and results were put into relevant matrices as:

$$R_{Trust\ in\ government} = \begin{bmatrix} 0 & 0.39 & 0.41 & 0.13 & 0.07 \\ 0 & 0.3 & 0.51 & 0.15 & 0.04 \\ 0 & 0.18 & 0.67 & 0.12 & 0.03 \\ 0 & 0.21 & 0.37 & 0.26 & 0.16 \end{bmatrix}$$

$$R_{Citizen'ssocial\ charateristics} = \begin{bmatrix} 0 & 0.27 & 0.62 & 0.0.08 & 0.03 \\ 0 & 0.45 & 0.31 & 0.13 & 0.11 \\ 0 & 0.64 & 0.24 & 0.12 & 0 \\ 0 & 0.34 & 0.51 & 0.15 & 0 \end{bmatrix}$$

$$R_{Security} = \begin{bmatrix} 0 & 0.1 & 0.74 & 0.14 & 0.02 \\ 0 & 0.54 & 0.38 & 0.06 & 0.02 \\ 0 & 0.35 & 0.49 & 0.16 & 0 \\ 0 & 0.46 & 0.37 & 0.17 & 0 \end{bmatrix}$$

$$R_{Privacy} = \begin{bmatrix} 0 & 0 & 0.27 & 0.56 & 0.17 \\ 0 & 0 & 0.17 & 0.27 & 0.57 \end{bmatrix}$$

$$R_{Infomration\ quality} = \begin{bmatrix} 0.2 & 0.59 & 0.19 & 0.02 & 0 \\ 0.13 & 0.64 & 0.19 & 0.04 & 0 \\ 0.28 & 0.39 & 0.26 & 0.05 & 0.02 \\ 0.34 & 0.50 & 0.14 & 0.02 & 0 \\ 0 & 0.32 & 0.58 & 0.07 & 0.03 \end{bmatrix}$$

$$R_{Service\ quality} = \begin{bmatrix} 0.21 & 0.48 & 0.28 & 0.02 & 0.01 \\ 0.26 & 0.57 & 0.17 & 0 & 0 \\ 0.32 & 0.49 & 0.17 & 0.02 & 0 \\ 0 & 0.51 & 0.24 & 0.18 & 0.07 \\ 0 & 0 & 0.21 & 0.61 & 0.18 \end{bmatrix}$$

$$R_{Maintenance\ and\ support} = \begin{bmatrix} 0.29 & 0.32 & 0.31 & 0.08 & 0 \\ 0.24 & 0.27 & 0.4 & 0.09 & 0 \\ 0 & 0 & 0 & 0.27 & 0.73 \\ 0.21 & 0.53 & 0.14 & 0.12 & 0 \\ 0 & 0 & 0.79 & 0.04 & 0.17 \\ 0 & 0.11 & 0.58 & 0.17 & 0.14 \end{bmatrix}$$

$$R_{Website\ design} = \begin{bmatrix} 0.51 & 0.43 & 0.06 & 0.06 & 0 \\ 0.45 & 0.38 & 0.17 & 0 & 0 \\ 0.44 & 0.42 & 0.12 & 0.02 & 0 \\ 0.13 & 0.71 & 0.12 & 0.03 & 0.01 \\ 0.24 & 0.23 & 0.48 & 0.03 & 0.02 \\ 0.05 & 0.48 & 0.21 & 0.2 & 0.06 \\ 0.21 & 0.39 & 0.29 & 0.09 & 0.02 \end{bmatrix}$$

The evaluation result of indices was computed as:

$$B_{Usability} = W_{Usability} \times R_{Usability} = [0.3913, 0.3043, 0.2173, 0.0869] \times \begin{bmatrix} 0 & 0.71 & 0.19 & 0.1 & 0 \\ 0 & 0.59 & 0.22 & 0.19 & 0 \\ 0 & 0.55 & 0.27 & 0.08 & 0.1 \\ 0 & 0.42 & 0.37 & 0.09 & 0.12 \end{bmatrix} = [0, 0.6134, 0.2321, 0.1222, 0.0322]$$

$$B_{Trust\ in\ government} = W_{Trust\ in\ government} \times R_{Trust\ in\ government}$$

$$= [0.2974, 0.2333, 0.2187, 0.2666] \times \begin{bmatrix} 0 & 0.39 & 0.41 & 0.13 & 0.07 \\ 0 & 0.3 & 0.51 & 0.15 & 0.04 \\ 0 & 0.18 & 0.67 & 0.12 & 0.03 \\ 0 & 0.21 & 0.37 & 0.26 & 0.16 \end{bmatrix}$$

$$= [0, 0.2813, 0.4861, 0.1692, 0.0794]$$

$$B_{Citizen'social\ characteristics} = W_{Citizen'social\ characteristics} \times R_{Citizen'social\ characteristics}$$

$$= [0.2413, 0.2758, 0.1724, 0.3103] \times \begin{bmatrix} 0 & 0.27 & 0.62 & 0.0.08 & 0.03 \\ 0 & 0.45 & 0.31 & 0.13 & 0.11 \\ 0 & 0.64 & 0.24 & 0.12 & 0 \\ 0 & 0.34 & 0.51 & 0.15 & 0 \end{bmatrix}$$

$$= [0, 0.4063, 0.4356, 0.1227, 0.0379]$$

$$B_{Security} = W_{Security} \times R_{Security} = [0.2909,0.3090,0.2181,0.1818] \times \begin{bmatrix} 0 & 0.1 & 0.74 & 0.14 & 0.02 \\ 0 & 0.54 & 0.38 & 0.06 & 0.02 \\ 0 & 0.35 & 0.49 & 0.16 & 0 \\ 0 & 0.46 & 0.37 & 0.17 & 0 \end{bmatrix} = [0,0.3559,0.5068,0.1251,0.0120]$$

$$B_{Privacy} = W_{Privacy} \times R_{Privacy} = [0.6234,0.3766] \times \begin{bmatrix} 0 & 0 & 0.27 & 0.56 & 0.17 \\ 0 & 0 & 0.17 & 0.27 & 0.57 \end{bmatrix} = [0,0,0.2323,0.4508,0.3206]$$

$$B_{Information\ quality} = W_{Information\ quality} \times R_{Information\ quality} = [0.2122,0.1856,0.1644,0.2387,0.1989] \times \begin{bmatrix} 0.2 & 0.59 & 0.19 & 0.02 & 0 \\ 0.13 & 0.64 & 0.19 & 0.04 & 0 \\ 0.28 & 0.39 & 0.26 & 0.05 & 0.02 \\ 0.34 & 0.50 & 0.14 & 0.02 & 0 \\ 0 & 0.32 & 0.58 & 0.07 & 0.03 \end{bmatrix} = [0.1938,0.4911,0.2671,0.0386,0.0093]$$

$$B_{Service\ quality} = W_{Service\ quality} \times R_{Service\ quality} = [0.2272,0.2070,0.2222,0.1818,0.1616] \times \begin{bmatrix} 0.21 & 0.48 & 0.28 & 0.02 & 0.01 \\ 0.26 & 0.57 & 0.17 & 0 & 0 \\ 0.32 & 0.49 & 0.17 & 0.02 & 0 \\ 0 & 0.51 & 0.24 & 0.18 & 0.07 \\ 0 & 0 & 0.21 & 0.61 & 0.18 \end{bmatrix} = [0.1726,0.4286,0.2141,0.1403,0.0441]$$

$$B_{Maintenance\ and\ support} = W_{Maintenance\ and\ support} \times R_{Maintenance\ and\ support} = [0.44,0.1395,0.1162,0.2093,0.1627,0.1976] \times \begin{bmatrix} 0.51 & 0.43 & 0.06 & 0.06 & 0 \\ 0.45 & 0.38 & 0.17 & 0 & 0 \\ 0.44 & 0.42 & 0.12 & 0.02 & 0 \\ 0.13 & 0.71 & 0.12 & 0.03 & 0.01 \\ 0.24 & 0.23 & 0.48 & 0.03 & 0.02 \\ 0.05 & 0.48 & 0.21 & 0.2 & 0.06 \\ 0.21 & 0.39 & 0.29 & 0.09 & 0.02 \end{bmatrix}$$

$$= [0.2050,0.3111,0.4646,0.1443,0.1401]$$

$$B_{Website\ design} = W_{Website\ design} \times R_{Website\ design} = [0.1744,0.1356,0.1201,0.1143,0.0775,0.1841,0.1937] \times \begin{bmatrix} 0.51 & 0.43 & 0.06 & 0.06 & 0 \\ 0.45 & 0.38 & 0.17 & 0 & 0 \\ 0.44 & 0.42 & 0.12 & 0.02 & 0 \\ 0.13 & 0.71 & 0.12 & 0.03 & 0.01 \\ 0.24 & 0.23 & 0.48 & 0.03 & 0.02 \\ 0.05 & 0.48 & 0.21 & 0.2 & 0.06 \\ 0.21 & 0.39 & 0.29 & 0.09 & 0.02 \end{bmatrix} = [0.2861,0.4399,0.1937,0.0729,0.0176]$$

The evaluation matrices R was created based on the above matrices:

$$R = \begin{bmatrix} Usability \\ Trust\ in\ government \\ Citizen's social\ charactersitics \\ Security \\ Privacy \\ Information\ quality \\ Service\ quality \\ Maintenance\ and\ support \\ Website\ design \end{bmatrix} = \begin{bmatrix} 0 & 0.6134 & 0.2321 & 0.1222 & 0.0322 \\ 0 & 0.2813 & 0.4861 & 0.1692 & 0.0794 \\ 0 & 0.4063 & 0.4356 & 0.1227 & 0.0379 \\ 0 & 0.3559 & 0.5068 & 0.1251 & 0.0120 \\ 0 & 0 & 0.2323 & 0.4508 & 0.3206 \\ 0.1938 & 0.4911 & 0.2671 & 0.0386 & 0.0093 \\ 0.1726 & 0.4286 & 0.2141 & 0.1403 & 0.0441 \\ 0.2050 & 0.3111 & 0.4646 & 0.1443 & 0.1401 \\ 0.2861 & 0.4399 & 0.1937 & 0.0729 & 0.0176 \end{bmatrix}$$

Finally, the comprehensive overall evaluation matrix $B_{Overall}$ was calculated by:

$$B_{Overall} = W \times R = [0.0892, 0.1531, 0.132, 0.129, 0.1496, 0.0724, 0.1006, 0.0489, 0.1252]$$
$$\times \begin{bmatrix} 0 & 0.6134 & 0.2321 & 0.1222 & 0.0322 \\ 0 & 0.2813 & 0.4861 & 0.1692 & 0.0794 \\ 0 & 0.4063 & 0.4356 & 0.1227 & 0.0379 \\ 0 & 0.3559 & 0.5068 & 0.1251 & 0.0120 \\ 0 & 0 & 0.2323 & 0.4508 & 0.3206 \\ 0.1938 & 0.4911 & 0.2671 & 0.0386 & 0.0093 \\ 0.1726 & 0.4286 & 0.2141 & 0.1403 & 0.0441 \\ 0.2050 & 0.3111 & 0.4646 & 0.1443 & 0.1401 \\ 0.2861 & 0.4399 & 0.1937 & 0.0729 & 0.0176 \end{bmatrix}$$

$$= [0.0772, 0.3463, 0.3406, 0.1697, 0.0837]$$

The appraisal vector $B_{Overall}$ was deffuzified using equation 22: $a_{Overall} = 53.6950$.

The overall trust in e-Gov services of the Tehran municipality website was computed 53.6950 which is in good status. Accordingly, the indices readiness score can be calculated by deffuzification of relevant appraisal vector B_i using equation 22. Table 11 and Figure 4 show the readiness score of indices.

Table 11. Readiness score of indices

Index	Readiness Score	Current Status
Usability	43.8938	Fair
Trust in government	57.8369	Good
Citizen's social characteristics	52.0741	Good
Security	54.4540	Good
Privacy	82.7125	Very Good
Information quality	42.6397	Fair
Service quality	44.8903	Fair
Maintenance and support	54.4194	Good
Website design	39.2269	Fair

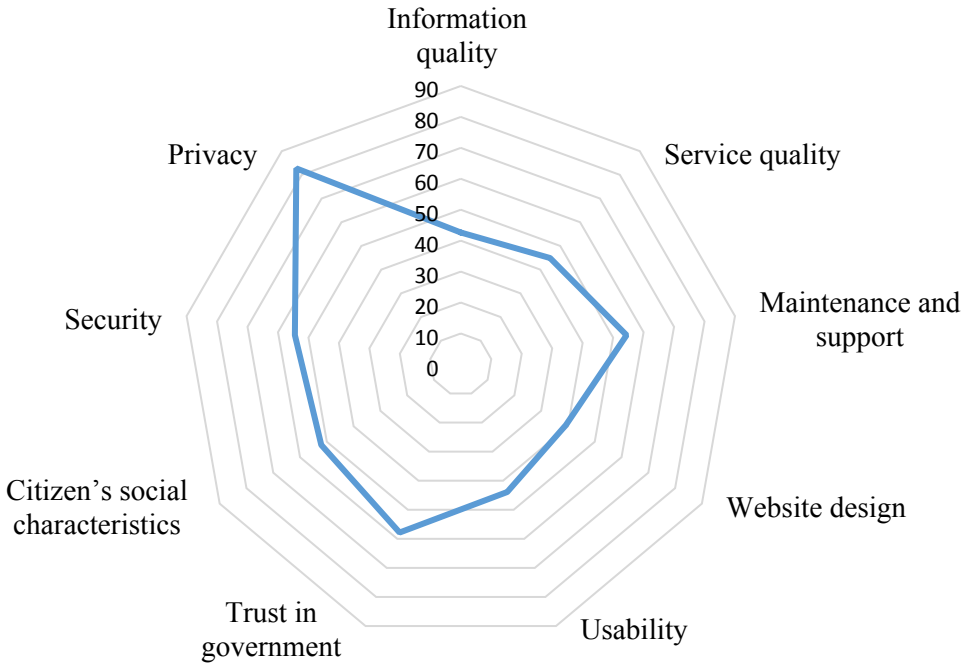

Figure. 4 The readiness score of indices in E-Gov services of Tehran municipality

The overall readiness status of trust in e-Gov services in Tehran municipality is Good whose readiness score is 53.69 (out of 100) but the readiness score denotes that the trust in e-Gov services is below the par and needs to be improved.

The website's usability is in fair condition and its readiness score is 43.89. The vast majority of respondents found it difficult to use e-Gov services comfortably aimed at fulfilling their requirements. Citizens were not at ease to find their required e-services and information. Moreover, the absence of an appropriate search engine and simple menu hampered the ease of use of e-Gov services.

Trust in government is another critical index that assesses government or state agencies reputation and government trustworthiness in delivered e-services. The index readiness score is in Good status whose readiness score is 57.83. Respondents believed that the Tehran municipality has a good reputation among people and many citizens hailed the organization as a reliable and trustable entity. Considering citizen's interest in delivered e-services was not assessed well because people did not feel that their interest is well-considered in services. Organization trustworthy with citizens

is below the par and some respondents believed that in some cases, the organization is not as honest as expected with people in delivering information and services.

Citizen's social characteristics intend to evaluate the citizen's characteristics facing with e-Gov services. The readiness score is 52.07 and is in good status. People have sufficient information and knowledge about the internet and they can use it easily but people never showed positive feedback regarding their last experience with e-Gov services which decreased citizen's trust in the current delivered services.

Security index intends to evaluate the required infrastructure for transferring information between the user's device and server whose readiness score is 54.45 which is seen in Good status. The e-Gov service of the Tehran municipality website was equipped with password entry but there was an absence of a virtual keyboard for entering the password. Moreover, all data was encrypted between the server and user's browser which decreased data leakage on data exchange.

Privacy keeps the user's information confidential and avoids sharing it with unknown people and other organizations. The readiness score for Tehran municipality is 82.71 which is seen in very Good status. The vast majority of respondents believed that their data have never been shared with irrelevant and unknown parties.

Information quality has to check the completeness, accuracy and precision of delivered information on the website. The readiness score is 42.63 and is in fair condition. Respondents believed that the delivered information did not have high quality because the presented information was not updated based on the latest changes and was not as precise as they expected.

The service quality index evaluates different dimensions of e-services such as service reliability, meeting citizen's requirements and effectiveness. The readiness score is 44.89 which is in Fair status. Many respondents believed that delivered e-services did not fulfil their requirements completely. Moreover, delivered e-services were not as reliable as respondents expected such that citizens were likely to face up to system breakdown while doing online transactions. Website responsiveness after each click is also another indicator that assesses website response speed after each click. Most respondents are satisfied with responsiveness quality.

Maintenance and support assess different existed facilities on the website to guide and help users to use services more efficiently. The readiness score is 54.41 which is in Good status. The vast majority of respondents believed that there was no useful online support for guiding users during

an online transaction. In addition to that, there was an absence of a user manual for training users to use the e-services more effectively.

Website design is made of two parts including visual beauty and technical compatibility whose readiness score is 39.22 which is in fair status. The website design index received the lowest readiness score. Visual beauty assesses the website attraction such as color, font and design. The respondents believed that the website visual beauty did not appeal to them and more attractive font and color should have been used. Additionally, the website did not enjoy a simple and same design on all web pages which relegated website beauty and integrity. The strongest point in website design was the compatibility with different systems and browsers.

5. Sensitivity Analysis

Sensitivity analysis was applied for validating the robustness and stability of the proposed framework for assessing trust in e-Gov services. It is so critical to evaluate how the proposed framework works in different environments. Moreover, the test was conducted to eliminate the potential human expert's judgments bias and discrimination which might have any possible impact on the final result. In this research, the sensitivity analysis was conducted by changing the maximum weight of the index (Trust in government) from 0.1 to 0.9 and check the influence on other indices. The impact of incremental change in Trust in the government index is shown in Table 12 through nine runs. Subsequently, the change of other indices weights was observed. As shown in Table 12 and Figure 5, the value weights of indices were changed but the ranking remained the same which shows the high stability and robustness of the proposed framework.

Table 12 Sensitivity analysis

Index	Normalized weight	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9
Usability	.0892	.0951	.0832	.0753	.0597	.0463	.0327	.0201	.0079	.0034
Trust in government	**.1531**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
Citizen's social characteristics	.1320	.1381	.1259	.1137	.1028	.0889	.0759	.0619	.0433	.195
Security	.1290	.1365	.1226	.1053	.0995	.0859	.0728	.0541	.0403	.0163
Privacy	.1496	.1612	.1427	.1301	.1119	.1048	.0925	.0733	.0541	.0383
Information quality	.0724	.0751	.0673	.0545	.0431	.0302	.0129	.0039	.0015	.0008
Service quality	.1006	.1069	.0953	.0824	.0692	.0569	.0414	.0309	.0176	.0078
Maintenance and support	.0489	.0514	.0435	.0309	.0204	.0056	.0027	.0007	.0005	.0001
Website design	.1252	.1357	.1195	.1078	.0961	.0814	.0691	.0551	.0348	.0138
Total	1	1	1	1	1	1	1	1	1	1

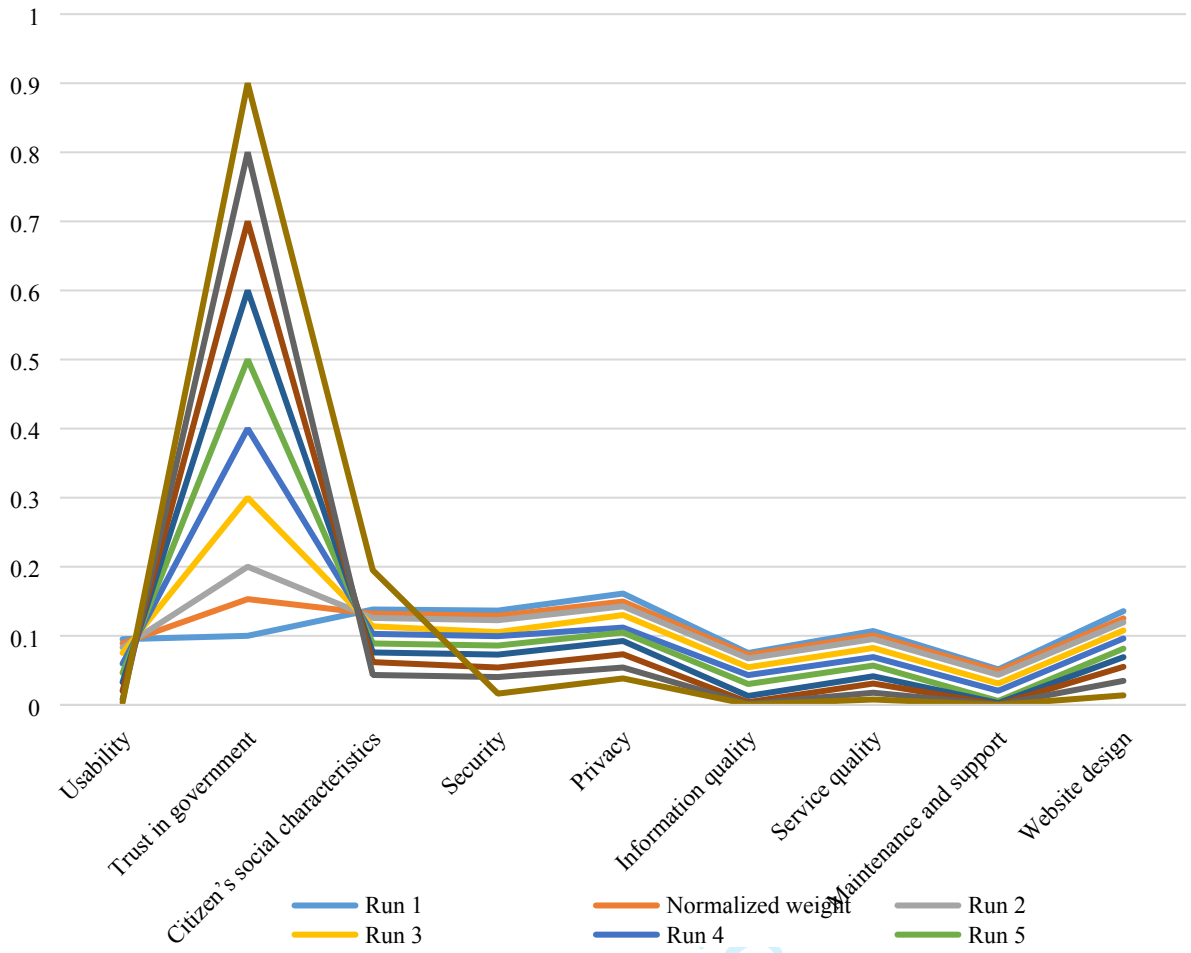

Figure. 5 Sensitivity analysis

6. Results and Discussion

The framework was proposed for assessing trust in e-Gov for state agencies and the framework can be used for evaluating the readiness of trust in e-Gov services by assigning a number between zero to one hundred. Table 10 and Figure 3 show the proposed framework comprised of 9 indices and 41 indicators. The framework determined the importance of indices and indicators by assigning weight.

The most important index is "trust in government" whose weight value is 0.1531. The index mostly assesses citizens' opinions about how much they can rely on and depend on the government. The high importance of the index in enhancing trust in e-Gov was supported by (Aljazzaf, 2019; Pappas et al., 2018). In this index, Government trustworthiness was computed as the most important

indicator which evaluates how much people can trust and depend on government or state agencies. Government or agencies reputation is the second most significant indicator assessing government or agencies credibility among citizens. The third indicator is Government honesty in e-services evaluating how frank and honest government or agencies is in delivering e-services. The last important indicator is considering the citizen's trust in e-services. The indicator assesses how government or agencies care about considering the citizen's interest in delivered services.

The second most important index is privacy whose weight value is 0.1496. The index assesses government concerns and actions about keeping citizen's private information confidential. The significantly important influence of the index on increasing trust in e-Gov services was also supported by (Abu-Shanab, 2019; Aljazzaf, 2019; Alzahrani et al., 2018; Ranaweera, 2016). The index is comprised of two indicators such as avoiding abusing citizen's personal information and avoiding sharing citizen's information with unknown people whose weight value are equal to 0.6234 and 0.3766 respectively.

Citizen's social characteristics are the third most important index which evaluates user's behavior and characteristics for a trusted third party. Different studies emphasized the significant role of citizen's characteristics in enhancing citizen's trust in e-Gov services (Alzahrani et al., 2017, 2018). Social influence was computed as the most important indicator. The indicator assesses the important people (such as celebrities) efforts and behavior into encouraging citizens to use e-Gov services. Disposition to trust is the second most important indicator which assesses the user's willingness to trust a third party without having credible and sufficient information. Since e-Gov is delivered on the internet, User's internet knowledge is so crucial in better usage of e-services which was considered as the third indicator. Users' experience has a direct impact on the user's intention to use e-Gov services. This was ranked as the fourth indicator.

Security index is the fourth important index. The index evaluates the required facilities for exchanging information between user's browsers and website servers securely. Many studies supported the significant role of security in boosting up citizen's trust in further usage of e-Gov services (Abu-Shanab, 2019; Ejdys et al., 2019; Carter and Liu, 2018; Aloud and Ibrahim, 2018; Alzahrani et al., 2018, 2017; Ranaweera, 2016). Having a password for entering into a user account is the main indicator. Data encryption is the second most important indicator intending to prevent any potential leakage by encoding transferred information. The third important indicator is containing a virtual keyboard for entering a password which enables users to keep their personal

information confidential from prospective hackers. The last indicator is a security code image. The indicator contributes to increasing security at the User Interface (UI).

Website design is the fifth most important index. The index mostly assesses the website technical flexibility and visual beauty. The significant effect of website design in increasing trust in e-Gov was highlighted by (Muttaqin and Susanto, 2019; Alzahrani et al., 2018). The technical features of the website including compatibility with different browsers and systems were obtained as the most two important indicators. The appealing and suitable font on the web pages is the third and fourth indicators that intend to enhance the website design beauty. Simple and same design on all web pages are the fifth and sixth indicators that increase webpages integrity. Displaying time, date and weather condition is the least important indicator.

Service quality is the sixth important index that assesses delivered e-Gov services from different aspects. The high importance of the index in enhancing trust in e-Gov services was supported by (Santa et al., 2019; Alzahrani et al., 2018; Antoni et al., 2018; Pappas et al., 2018; Nulhusna et al., 2017). Meeting citizen's requirement is the most chief indicator which is assessed by the frequency of e-services. The second indicator is how effective e-Gov services are for citizens. Service reliability is the third indicator evaluating website resistance against any potential technical problem that occurs during online transactions. The least important indicator is website responsiveness after each click. The indicator is evaluated based on the required time to respond after each click. Higher speed response let users feel more comfortable and convenient using services.

Usability is the seventh index that evaluates the required facilities on websites for increasing ease of use of e-Gov services. The direct influence of usability on increasing trust in e-Gov services was supported by (Abu-shanab, 2019; Aljazzaf, 2019; Tsui, 2019; Carter and Liu, 2018; Xie et al., 2017; Ranaweera, 2016). Easy to use and find e-Gov services and information are the most important indicators. The indicators evaluate how easy to reach e-services and information by citizens. Search engine is another indicator that is conducive to reaching e-services and information. Simple menu is the least important indicator. The indicator evaluates how easy to use the menu by users for reaching general information.

Information quality is the eighth index. The index assesses the quality of website information based on different aspects such as precision, accuracy and updating. The highly significant influence of information quality on leveraging trust in e-Gov services was highlighted by (Abu-Shanab, 2019;

Santa et al., 2019; Alzahrani et al., 2018; Antoni et al., 2018; Aloud and Ebrahim, 2018; Nulhusna et al., 2017; Ranaweera, 2016). Delivering the last updated information is the most important indicator. Presenting complete information is the second indicator that enables users to fulfil more requirements. Ease of information understanding is the third indicator assessing how easy to understand information by users regardless of their educational background. Information accuracy and precision are the two least important indicators having a direct effect on information quality.

The last important index is Maintenance and support. The index assesses different facilities on the website for guiding and supporting users during online transactions. The highly important effect of maintenance and support in trust in e-Gov was supported by (Muttaqin and Susanto, 2019). Sending an email to users after registration is the most important indicator to inform users about the status of a registered request. Website user manual is the second indicator that intends to give practical and useful hints about using e-Gov services. Online support is the third indicator that helps citizens to use e-Gov services while carrying out an online transaction. Sending tracking number by email or SMS is the fourth indicator which assures users that their requests are well-received and registered. Online maintenance is the fifth indicator providing supporting services in the time of difficulties or when the e-Gov services face up to any possible crashes. The least important indicator is displaying an error message to prevent users from further operation while conducting online transactions.

7. Implications

7.1 Theoretical contribution

The main theoretical implications of the current study are:

- One of the main theoretical implications is extending the narrow view of assessing trust in e-Gov services by considering various indices and indicators. The previous studies have highlighted limited aspects of trust in e-Gov services (Alzahrani et al., 2017, 2018) while in the current studies wider dimensions were taken into account for more precise and exact assessment. Mensah et al. (2021) have considered the following indices "Trust in government", "Trust in internet", Information quality and "Information accessibility". Munyko (2020) mostly concentrated on three aspects of social characteristics, security and privacy issues. While the current research exceeds the previous studies boundaries and provides more comprehensive and extensive aspects of trust within e-Gov including:

"usability", "trust in government", social characteristics", "security", "privacy", information quality", "service quality", maintenance and support" and "website design".

- The appropriate research methodology (IVIFS AHP) determines the importance of indices and indicators. The findings recognize the priority of indices and indicators by assigning a quantitative value. Meanwhile, the previous studies determined whether the given factors have any effects on further use of e-Gov services by citizens. Hammouri et al. (2021) used the empirical study to assess the impact of given factors on increasing citizen's trust in e-Gov services. Almaiah and Nasereddin (2020) applied SEM method to see the given indices for boosting up trust in increasing further use of e-Gov services. However, our findings denote the "Trust in government", "Privacy", "social characteristics" and "Security" are recognized as the most important indices and have the most effect on increasing user's intention to use the services for fulfilling their requirements. In addition to it, the least effective indices are also determined including "Maintenance and support", "Information quality" and "usability".
- The third important theoretical implication is associated with research methodology. The previous studies have not applied a suitable method for assessing the concept of trust which is a subjective concept and involves a high level of vagueness. Mensah et al. (2021) used SEM method to assess the trust dimensions for increasing user's intention to use e-Gov services. Muttaqin and Susanto (2019) have used the hypothesis testing approach to check whether the given factors increase citizen's trust in e-Gov services usage. Statistical methods have vastly used in relevant studies which cannot model uncertainty associated with the concept of trust. In the current study, IVIFS is applied to better capture the problem's vagueness and model the experts' judgments in an interval.
- The fourth theoretical implication is proposing a stable and robust method to evaluate the readiness score of indices and indicators for different case studies. The previous studies mostly determined potential associations between the number of factors with the concept of trust in e-Gov services. They did not make their finding applicable for any potential case studies for assessing the readiness status of trust in e-Gov services. Al-Swidi and Enazi (2021) have applied SEM method to explore the association between different factors. The study did not make its findings practical for real case studies. Ejdys et al. (2019) used hypothesis testing to investigate the effective factors on the enhancement of trust in e-Gov

services. The studies did not propose any practical approach for assessing the readiness status of case studies under the given factors. While in this study Fuzzy Evaluation Method is suggested to make the findings practical and applicable for case studies by investigating the readiness score as well as providing some practical advice for decision makers.

7.2 Implications for practice

The research has shown a great practical implication which are:

- The study highlighted the high importance of citizen's trust in e-Gov services as one of the strongest enablers to increase citizen's participation with e-Gov services, therefore, policy-makers and state agencies managers are supposed to take this issue into account in order to increase people's involvement with online services. The current research findings show that for fulfilling such an objective, policy-makers are expected to consider different factors which assure user's trust in e-Gov services. Citizen's trust in government is seen as the most important factor which predicts further use of e-Gov. Government agencies honesty and trustworthiness with citizens are key factors for enhancing people's trust in government. Moreover, policy-makers and managers are expected to consider citizen's interest in delivered online services, which leads to fulfilling citizen's requirements more easily and comfortably, aimed at enhancing people's trust in government agencies.
- Since e-Gov contains huge personal citizen's information, policymakers are expected to avoid any violation of data privacy such as sharing with unknown users or organizations. The findings showed that any infringement of citizen's privacy has a detrimental effect on citizen's trust in e-Gov. In addition to that, providing a secure platform for online transaction is so critical that policy-makers are supposed to take any required actions to prevent any data leakage during an online transaction by potential hackers and law-breakers.
- It is highly required to invite well-reputed people to encourage society to apply e-Gov services. Since society intends to follow up well-reputed people footsteps as a reliable part of society, they play a crucial role in enhancing people's trust in using e-Gov services. Thus, policymakers should pay more attention to get well-reputed people engaged with e-Gov services and ask them to propagate e-Gov services within followers.
- Website is a gateway enabling citizens to reach online services and needed information. The study findings urge policymakers to provide e-Gov services through an appealing user

interface. An attractive design has a direct influence on citizen's trust in e-Gov services which should be considered as another important enabler to enhance citizen's participation. Moreover, ease of use of e-Gov services is another factor needed to be considered by policy-makers to create a comfortable and convenient virtual environment for citizens to use e-Gov services.

- In addition to non-technical issues, website technical features are highly recommended to be given as another enabler to enhance citizen's trust. E-Gov software developers are supposed to provide online support to guide people more effectively for better use of e-Gov services. Applying strong infrastructure for accelerating website response makes people more satisfied with services. Therefore, policymakers are required to make a considerable investment in improving website infrastructure such as deploying website servers inside the country rather than overseas. The findings showed that such actions help to enhance citizen's trust.
- Policymakers are expected to provide a wide range of services to meet users' requirements. The E-Gov platform should be equipped with as many services as people need to fulfil. Proposing various number of services persuade people to apply the services more frequently in their daily life and they are much more exposed to the e-Gov services platform which leads to leveraging users 'trust in e-Gov services.

8. Conclusions

With the massive development of ICT-based applications in a different sphere, many state agencies have the intention to apply such technologies to deliver online services to citizens. Despite massive investment in e-Gov infrastructure, many people still prefer to use a conventional method to fulfil their requirements rather than using e-Gov services. One of the key factors impeding citizen's participation in e-Gov services is the lack of citizen's trust in e-Gov. In this paper, firstly, the most relevant studies associated with trust in e-Gov were reviewed and the most important indices and indicator were determined as usability, trust in government, information quality, security, privacy, service quality, maintenance and support, website design and citizen's social characteristics then they were assigned weight using AHP method. Due to the subjective concept of trust, Fuzzy Sets Theory was applied to model the existed ambiguity in the problem. Moreover, the absence of experts' judgments on allocating a single membership function for fuzzy numbers caused us to

apply Interval-valued intuitionistic fuzzy sets to define membership function in an interval [0,1]. The final results showed that the most important indices are Trust in government, privacy, citizen's social characteristics, security, website design, service quality, usability, information quality, maintenance and support respectively.

8.1 Unique contributions

- Introducing a comprehensive set of indices and indicators to evaluate trust in e-Gov. They were validated using Fuzzy Delphi. The indices and indicators were collected from previous researches and categorized by previous studies and expert's judgments. By considering the indices and indicators, wider aspects of trust in e-Gov services were evaluated comparing to previous studies.
- Since trust is a subjective concept and there is an inherent ambiguity in indices and indicators, IVIFS was applied for modelling inherent existed uncertainty. Moreover, experts did not have agreement on a single membership function for fuzzy number, Interval-valued intuitionistic fuzzy sets were applied to model their judgment in intervals [0,1] while previous studies mostly used statistical methods which were not able to model the problem vagueness.
- Recognizing the priority of indices and indicators is so essential in conducting effective management of citizen's participation. AHP method was applied to calculate the preference of indices and indicators by assigning weight.
- Fuzzy Evaluation Method was applied to evaluate the readiness score of any potential case studies. The method can recognize and visualize the weakness and strength of trust in e-Gov services. The final results can help policy decision-makers and state agencies managers to observe the status of trust in e-Gov services and make the right decisions to leverage citizen's trust.
- Sensitivity analysis was carried out to check the stability and robustness of the proposed framework. The finding showed that the incremental changes in the highest important index (trust in government) did not affect the rest of the indices ranking.
- Finally, the framework was applied for a state agency in Iran E-Gov services of Tehran Municipality) to recognize the readiness score of indices and indicators. The final results showed that the trust in e-Gov is in good status with a readiness score of 53.69 (out of 100).

References

Abdel-Basset, M., Zhou, Y., Mohamed, M., & Chang, V. (2018). A group decision making framework based on neutrosophic VIKOR approach for e-government website evaluation. Journal of Intelligent and Fuzzy Systems, 34(6), 4213-4224.

Abu-Shanab, E. (2019). Predicting trust in e-government: Two competing models. Electronic Government, 15(2), 129-143.

Al-Swidi, A. K., & Enazi, M. A. (2021). The trust in the intermediaries and the intention to use electronic government services: A case of a developing country. *Electronic Government, 17*(1), 27-54.

Alarabiat, A., Soares, D., & Estevez, E. (2021). Determinants of citizens' intention to engage in government-led electronic participation initiatives through Facebook. *Government Information Quarterly, 38*(1).

Aljazzaf, Z. M. (2019). Evaluating trust in E-government: The case of Kuwait. Paper presented at the ACM International Conference Proceeding Series.

Almaiah, M. A., & Nasereddin, Y. (2020). Factors influencing the adoption of e-government services among Jordanian citizens. *Electronic Government, 16*(3), 236-259.

Alomari, M., Woods, P., & Sandhu, K. (2012). Predictors for e-government adoption in Jordan: Deployment of an empirical evaluation based on a citizen-centric approach. *Information Technology and People, 25*(2), 207-234.

Aloud, H., & Ibrahim, Y. (2018). Factors influencing the citizen trust to adopt e-government services in Saudi Arabia. Journal of Theoretical and Applied Information Technology, 96(15), 5015-5030.

Alzahrani, L., Al-Karaghouli, W., & Weerakkody, V. (2017). Analysing the critical factors influencing trust in e-government adoption from citizens' perspective: A systematic review and a conceptual framework. International Business Review, 26(1), 164-175.

Alzahrani, L., Al-Karaghouli, W., & Weerakkody, V. (2018). Investigating the impact of citizens' trust toward the successful adoption of e-government: A multigroup analysis of gender, age, and internet experience. Information Systems Management, 35(2), 124-146.

Antoni, D., Apriliani, Herdiansyah, M. I., & Akbar, M. (2018). Critical factors of transparency and trust for evaluating e-government services for the poor. Paper presented at the Proceedings of the 2nd International Conference on Informatics and Computing, ICIC 2017.

Benaida, M., Namoun, A., & Taleb, A. (2018). Evaluation of the impact of usability in Arabic university websites: Comparison between Saudi Arabia and the UK. International Journal of Advanced Computer Science and Applications, 9(8), 365-375.

Carter, L., & Liu, D. (2018). Technology humanness, trust and e-government adoption. Paper presented at the ACIS 2018 - 29th Australasian Conference on Information Systems.

Chu, T.-C., & Nguyen, H. T. (2019). Ranking Alternatives with Relative Maximizing and Minimizing Sets in a Fuzzy MCDM Model. *International Journal of Fuzzy Systems, 21*(4), 1170-1186.

Dogan, O., Deveci, M., Canıtez, F., & Kahraman, C. (2019). A corridor selection for locating autonomous vehicles using an interval-valued intuitionistic fuzzy AHP and TOPSIS method. *Soft Computing*, 1-17.

Ejdys, J., Ginevicius, R., Rozsa, Z., & Janoskova, K. (2019). The role of perceived risk and security level in building trust in e-government solutions. E a M: Ekonomie a Management, 22(3), 220-236.

Guo, W., & Li, C. (2019). An Analysis of tourist satisfaction of Scenic spots in Pingliang based on Fuzzy Comprehensive Evaluation method. Paper presented at the Journal of Physics: Conference Series.

Habib, A., Alsmadi, D., & Prybutok, V. R. (2020). Factors that determine residents' acceptance of smart city technologies. *Behaviour and Information Technology, 39*(6), 610-623.

Hammouri, Q. M., Abu-Shanab, E. A., & Nusairat, N. M. (2021). Attitudes toward implementing E-government in health insurance administration. *International Journal of Electronic Government Research, 17*(2), 1-18.

Huang, Z., & Benyoucef, M. (2014). Usability and credibility of e-government websites. Government Information Quarterly, 31(4), 584-595.

Ismailova, R., & Kimsanova, G. (2017). Universities of the Kyrgyz Republic on the Web: accessibility and usability. Universal Access in the Information Society, 16(4), 1017-1025.

Joshi, P. R., & Islam, S. (2018). E-government maturity model for sustainable E-government services from the perspective of developing countries. Sustainability (Switzerland), 10(6).

Kamoun, F., & Almourad, M. B. (2014). Accessibility as an integral factor in e-government web site evaluation: The case of Dubai e-government. *Information Technology and People, 27*(2), 208-228.

Khan, S., Ab. Rahim, N. Z., & Maarop, N. (2019) Towards the development of a citizens' trust model in using social media for e-government services: The context of Pakistan. In: Vol. 843. Advances in Intelligent Systems and Computing,1002-1012.

Khan, S., Umer, R., Umer, S., & Naqvi, S. (2021). Antecedents of trust in using social media for E-government services: An empirical study in Pakistan. *Technology in Society, 64*.

Kumar, A., Pal, A., Vohra, A., Gupta, S., Manchanda, S., & Dash, M. K. (2018). Construction of capital procurement decision making model to optimize supplier selection using Fuzzy Delphi and AHP-DEMATEL. Benchmarking: An International Journal.

Kumar, R., Kumar, R., Sachan, A., & Gupta, P. (2020). An examination of the e-government service value chain. *Information Technology and People*. Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/ITP-09-2018-0438

Lolli, F., Ishizaka, A., Gamberini, R., Rimini, B., Ferrari, A. M., Marinelli, S., & Savazza, R. (2016). Waste treatment: an environmental, economic and social analysis with a new group fuzzy PROMETHEE approach. *Clean Technologies and Environmental Policy, 18*(5), 1317-1332.

Magboul, I. H. M., Abbad, M. M. M., Jaber, F. N. A., & AlQeisi, K. I. (2021). Antecedents and outcome of electronic government implementation in a service sector context. *International Journal of Electronic Governance, 13*(1), 21-47.

Mansoori, K. A. A., Sarabdeen, J., & Tchantchane, A. L. (2018). Investigating Emirati citizens' adoption of e-government services in Abu Dhabi using modified UTAUT model. *Information Technology and People, 31*(2), 455-481.

Manzoor, M., Hussain, W., Sohaib, O., Hussain, F. K., & Alkhalaf, S. (2019). Methodological investigation for enhancing the usability of university websites. Journal of Ambient Intelligence and Humanized Computing, 10(2), 531-549.

Mensah, I. K., & Adams, S. (2019). A Comparative Analysis of the Impact of Political Trust on the Adoption of E-Government Services. *International Journal of Public Administration*.

Mensah, I. K., Luo, C., & Abu-Shanab, E. (2021). Citizen use of e-government services websites: A proposed e-government adoption recommendation model (EGARM). *International Journal of Electronic Government Research, 17*(2), 19-42.

Munyoka, W. (2020). Electronic government adoption in voluntary environments – a case study of Zimbabwe. *Information Development, 36*(3), 414-437.

Muttaqin, M. H., & Susanto, T. D. (2019). The Effect of Website Components on User Trust in Increasing the Interest to Use Public Administration Service on E-Government Website. Paper presented at the Proceedings - 2019 International Conference on Computer Science, Information Technology, and Electrical Engineering, ICOMITEE 2019.

Nofal, M. I., Al-Adwan, A. S., Yaseen, H., & Alsheikh, G. A. A. (2021). Factors for extending e-government adoption in Jordan. *Periodicals of Engineering and Natural Sciences, 9*(2), 471-490.

Noori, A., Bonakdari, H., Morovati, K., & Gharabaghi, B. (2020). Development of optimal water supply plan using integrated fuzzy Delphi and fuzzy ELECTRE III methods—Case study of the Gamasiab basin. Expert Systems, e12568.

Nulhusna, R., Sandhyaduhita, P. I., Hidayanto, A. N., & Phusavat, K. (2017). The relation of e-government quality on public trust and its impact on public participation. Transforming Government: People, Process and Policy, 11(3), 393-418.

Oztaysi, B., Onar, S. C., Kahraman, C., & Yavuz, M. (2017). Multi-criteria alternative-fuel technology selection using interval-valued intuitionistic fuzzy sets. Transportation Research Part D: Transport and Environment, 53, 128-148.

Pappas, I. O., Kourouthanassis, P., Mikalef, P., & Giannakos, M. N. (2018). Combining system success factors with trust to explain e-government adoption using fsQCA. Paper presented at the Americas Conference on Information Systems 2018: Digital Disruption, AMCIS 2018.

Park, H., & Lee, T. D. (2018). Adoption of E-Government Applications for Public Health Risk Communication: Government Trust and Social Media Competence as Primary Drivers. *Journal of Health Communication, 23*(8), 712-723.

Pena-Lopez, I. (2016). UN e-Government Survey 2016. E-Government in Support of Sustainable Development.

Perez-Morote, R., Pontones-Rosa, C., & Núñez-Chicharro, M. (2020). The effects of e-government evaluation, trust and the digital divide in the levels of e-government use in European countries. Technological Forecasting and Social Change, 154, 119973.

Ramanayaka, K. H., Chen, X., & Shi, B. (2019). UNSCALE: A Fuzzy-based Multi-criteria Usability Evaluation Framework for Measuring and Evaluating Library Websites. IETE Technical Review, 36(4), 412-431.

Ranaweera, H. M. B. P. (2016). Perspective of trust towards e-government initiatives in Sri Lanka. SpringerPlus, 5(1), 1-11.

Saengchai, S., Sriyakul, T., & Jermsittiparsert, K. (2020). The impact of citizen trust, citizen disposition and favourable social characteristics on the adoption of e-government: Mediating roles of perceived behavioural control. *International Journal of Innovation, Creativity and Change, 12*(11), 375-393.

Santa, R., MacDonald, J. B., & Ferrer, M. (2019). The role of trust in e-Government effectiveness, operational effectiveness and user satisfaction: Lessons from Saudi Arabia in e-G2B. Government Information Quarterly, 36(1), 39-50.

Singh, P. K., & Sarkar, P. (2020). A framework based on fuzzy Delphi and DEMATEL for sustainable product development: A case of Indian automotive industry. Journal of Cleaner Production, 246, 118991.

Smith, M. L. (2010). Building institutional trust through e-government trustworthiness cues. *Information Technology and People, 23*(3), 222-246.

Tabaraee, E., Ebrahimnejad, S., & Bamdad, S. (2018). Evaluation of power plants to prioritise the investment projects using fuzzy PROMETHEE method. International Journal of Sustainable Energy, 37(10), 941-955.

Tella, A. (2019). The determinants of library and information science undergraduate students' first impression of university library websites. Education and Information Technologies, 24(1), 277-294.

Tooranloo, H. S., & Iranpour, A. (2017). Supplier selection and evaluation using interval-valued intuitionistic fuzzy AHP method. International Journal of Procurement Management, 10(5), 539-554.

Tsui, H.-D. (2019). Trust, Perceived Useful, Attitude and Continuance Intention to Use E-Government Service: An Empirical Study in Taiwan. IEICE Transactions on Information and Systems, 102(12), 2524-2534.

Twizeyimana, J. D., & Andersson, A. (2019). The public value of E-Government – A literature review. Government Information Quarterly, 36(2), 167-178.

United Nations (2018). United Nations E-government servey. Retreived from: https://publicadministration.un.org/Portals/1/Images/E-Government%20Survey%202018_FINAL%20for%20web.pdf

Verkijika, S. F., & De Wet, L. (2018a). Quality assessment of e-government websites in Sub-Saharan Africa: A public values perspective. Electronic Journal of Information Systems in Developing Countries, 84(2).

Verkijika, S. F., & De Wet, L. (2018b). A usability assessment of e-government websites in Sub-Saharan Africa. International Journal of Information Management, 39, 20-29.

Xie, Q., Song, W., Peng, X., & Shabbir, M. (2017). Predictors for e-government adoption: Integrating TAM, TPB, trust and perceived risk. Electronic Library, 35(1), 2-20.

Zhao, F., Scavarda, A. J., & Waxin, M. F. (2012). Key issues and challenges in e-government development: An integrative case study of the number one eCity in the Arab world. *Information Technology and People, 25*(4), 395-422.

Zhang, X., & Lam, J. S. L. (2019). A fuzzy Delphi-AHP-TOPSIS framework to identify barriers in big data analytics adoption: case of maritime organizations. Maritime Policy & Management, 46(7), 781-801.

Ziemba, P. (2018). NEAT F-PROMETHEE – A new fuzzy multiple criteria decision making method based on the adjustment of mapping trapezoidal fuzzy numbers. Expert Systems with Applications, 110, 363-380.