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A PROPOSED FRAMEWORK FOR THE ORGANIZATION READINESS ASSESSMENT OF IT INNOVATION ADOPTION IN E-GOVERNMENT ENVIRONMENT

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Abstract: *Most of developing countries are now experiencing revolution in e-government to deliver fluent and simple services for their citizens. But, the organization will face three main problems if it decided to modernize its IT infrastructure; firstly, there are many solutions of new technologies, how to choose between them. Secondly, what is the impact of the factors affect on those solutions? Thirdly, what is the degree of readiness each of these factors to comply this new changing? Therefore, a systematic approach to measure organization readiness for adopting this new solution is needed, this paper proposes a practical framework helps in answering these questions and assists decision makers in estimating organization readiness for adopting all IT suggested solutions and to compare between these solutions. Whereas, it will use Multi-Criteria Decision Making method to rank the alternatives, taking into account all the attributes and factors affect the result, finally, it assess the degree of readiness of these factors to accept the preferred solution.*

Keywords**:** *Multi Criteria Decision Making (MCDM), Analytic network process (ANP), Fuzzy analytic network process (FANP), E-government.*

1. Introduction

The last two decades have witnessed the wide diffusion of e-government adoption in many countries because it has many benefits for citizens and governments. For citizens, it can manage data, enhance public service delivery and expand communication channels. For governments, it will increase productivity, grow business economy, share global knowledge and have automated business processes and communications. Although all these benefits for e-government, there are many of drawbacks for it. Data of E-government system become increasingly inflating, operation flow more complicated and collaborative business more difficult, so that governments have to increase the IT budget costs, purchase more IT equipments, redesign and revise the E-government system to meet public requirements and their own demands [3].

Traditional IT infrastructures pose application life cycle management; software licensing and support; scalability; accountability; modifiability and physical security challenges to both public and private sector organizations [4].

In addition, there are replication of applications, insufficient exchange and logging details of client's data, difficulties in migration, integration and management for software and hardware, fragmentation of resources and low asset utilization, and power usage, air-conditioning and electronic waste could create biohazards, and finally absence of accountability and management policies. All these inefficiencies negatively affect the e-Government's ability to serve the government's organizations. Therefore, we need to migrate from traditional computing and adopt any new technology that solve all these problems and make systems up to date continuously, especially with speedy development in technology. This new technology should have set of characteristics can overcome all previous obstacles.There are many solutions have the potential to play a major part in addressing these inefficiencies and improving government service delivery. However, which of these solutions is suitable for the organization and the budget, easy for end-users to learn and use, compatible with existing systems, reliable to depend on, management accept or reject it, realize customer satisfaction and which one is harmony with organization's laws and regulations.

2. Background & Related Work

The Economist Intelligence Unit (EIU) stated that different corporate and international organizations have developed a variety of e-readiness models to participate in the global digital economy at the level of e-commerce, e-government and general ICT diffusion. It characterized e-readiness as the "state of play of a country's ICT infrastructure and the ability of its consumer, businesses and governments to use ICT to their benefit". Potnis and Pardo (2011) claimed that the quality of life for nations is tested through the process of e-readiness, thus it is essential to adopt ICT to prevent being in the lag within other nations and economies [4].

The present readiness assessment tools have been developed and are used for large-scale organizations or at country level. These tools, however, still have limitations and are un-suitable for small and medium organizations. As a result, few organizations can use these tools to identify ICT readiness and management frameworks for their business alignment [2].
Alghamdi et al., 2011 stated that the existing e-readiness tools fail to adequately measures of physical ICT infrastructure and that tools provided unsuitable parameters and factors in assessing the comprehensive e-readiness of organizations [1].

In addition (Azab et al., 2009) mention that, these tools mainly evaluate e-services and accessibility, support and usage of ICT but they are not directly focusing on the problems that exist in individual e-Government projects or on the internal factors affecting transformation of a government organization due to ICT adoption [9].

2.1 E-Government Readiness Assessment for Government Organizations in Developing Countries:

This proposed framework for assessing ICT readiness of e-government organizations in developing countries that focuses on technical issues, its idea is based on incorporating pertinent factors to an e-government context. Therefore, it comprises seven dimensions of ICT readiness assessment for government organizations including e-government strategy, user access, e-government program, ICT architecture, business process and information systems, ICT infrastructure, and human resources [1].

2.2 ICT Readiness assessment model for public and private organizations in developing country:

ICT readiness assessment model is designed to measure readiness of ICT utilization levels and ICT penetration levels in small and medium sized organizations in developing countries. This model is composed of indicators for the four main ICT factors where these four factors contain a total of 16 ICT sub-factors [2].

2.3 E-learning readiness assessment model:

This model has been developed to assess eLearning readiness of lecturers from institutions of higher learning in Kenya and determine the factors that influence eLearning readiness.
This model contains main parameters that are used to develop the hybrid model are; technological readiness, culture readiness, content readiness and demographics. In addition, each of these factors has sets of sub-factors each of which will be taken into consideration during the assessment period [3].

2.4 A Suggested framework for assessing electronic government readiness in Egypt:

They developed an e-Government appraisal framework encompassing several components such as people, technology, processes, and strategic planning.

The proposed framework adopts four phase model of e-Government that classifies e-Government into four dimensions: strategy, processes, technology, and people. In addition, it suggests a number of constructs under each dimension in the framework. The framework acts as a prototype in the form of a checklist. A public organization can verify the presence or absence of each construct under each dimension [9].

After reviewing the previous frameworks, we observed that, all frameworks are:

- Conceptual and not practical frameworks without identifying the steps, ways, tools of how to use it.
- Depend only on the factors that influence organization readiness.
- The assessment for only one solution and one objective not for many choices we can compare between them.
- There are no identifying critical success factors for that solution and is that solution be carried out or not.
- In case the rate of readiness is very low, there is no identifying for what is the decision, the reaction or the next step.

Therefore, we need a solution ensures overcoming all these defects. This solution necessary to measure the readiness degree of the organization in presence many alternatives to help the decision makers compare between them and prefer only one. In addition, This solution need to take into account that there are many factors have impact on the decision. These factors are interrelated and depending on each other. Finally, we need a solution should identify where are the shortage points in the organization and the degree of that shortage.The main objectives of this paper are to develop a framework including the associated factors for IT innovation readiness assessment and to achieve that three main goals. The framework is constructed using fuzzy analytic network process.

3. Analytic Hierarchy Process (AHP)

The AHP was developed in the 1980s by Saaty [10]. It is a systematic decision making method which includes both qualitative and quantitative techniques. It is being widely used in many fields for a long time. AHP is a theory of relative measurement with absolute scales of both tangible and intangible criteria based on the judgment of knowledgeable and expert people. How to measure intangibles is the

main concern of the mathematics of the AHP. It reduces a multidimensional problem into a one dimensional one. Decisions are determined by a single number for the best outcome or by a vector of priorities that gives an ordering of the different possible outcomes. We can also combine our judgments or our final choices obtained from a group when we wish to cooperate to agree on a single outcome.
Example to clarify AHP method; AHP method may aid the decision maker to set priorities and make the best decision. By reducing complex decisions to a series of pair-wise comparisons, and then synthesizing the results.

Step 1. Defining criteria and alternatives.
We define three criteria as:
1. Technological factors
2. Environmental factors
3. Organizational factors

And three alternatives as:
1. Current technology modifications (A1)
2. Adopt mobile technology and work from home (A2)
3. Adopt cloud computing (A3).

Step 2. Pair-wise comparisons among criteria according to table 1 is illustrated in table 2.

Table 1 The Fundamental Scale used for the judgments

Fundamental scales for relative importance	Scale	Reciprocal scale
Equal importance	1	1
Weakly more important	3	1/3
Strongly more important	5	1/5
Very strongly more important	7	1/7
Extreme importance	9	1/9

Table 2 Pair-wise comparisons among criteria

Criteria	Technological	Environmental	Organizational	Local Weight
Technological	1	7	5	0.7235
Environmental	1/7	1	1/3	0.0833
Organizational	1/5	3	1	0.1932

Step 3. Pair-wise comparisons among alternatives - by each criteria as illustrated in tables 3, 4 and 5.

Table 3 Pair-wise comparisons of alternatives, based on factor: Technological

Alternatives	A1	A2	A3	Local Weight
A1	1	5	3	0.5796
A2	1/5	1	7	0.3099
A3	1/3	1/7	1	0.1105

Table 4 Pair-wise comparisons of alternatives, based on factor: Environmental

Alternatives	A1	A2	A3	Local Weight
A1	1	5	5	0.6864
A2	1/5	1	3	0.2114
A3	1/5	1/3	1	0.1022

Table 5 Pair-wise comparisons of alternatives, based on factor: Organizational

Alternatives	A1	A2	A3	Local Weight
A1	1	5	3	0.5973
A2	1/5	1	5	0.2824
A3	1/3	1/5	1	0.1203

Step 4. Calculating overall priority scores.
From the above matrix and using http://www.healthstrategy.com/ahp/ahp.php web site to calculate the global weights as

A1	0.6131
A2	0.2710
A3	0.1160

Then the order of alternatives is A1, A2 and A3

Many researchers have long observed some weaknesses for using it. When the number of alternatives in the hierarchy increases, more comparisons between alternatives need to be made. This could easily cause confusion due to the excess of questions and hence the efficiency of the model. So a consistency check is required for the pair-wise comparison matrix. Therefore, whether the setting of the comparison matrix is scientific affects the correctness of AHP directly. When the comparison matrices are not consistent, we should adjust the elements in the matrixes and carry out a consistency test until they are consistent. Another defect of the AHP method can be considered as a complete aggregation method of the additive type. The problem with such aggregation is that compensation between good scores on some criteria and bad scores on other criteria can occur. Detailed and often important, information can be lost by such aggregation. Another important disadvantage of the AHP method is the artificial limitation of the use of the ***9***-point scale. Sometimes, the decision maker might find difficult to distinguish among them and tell for example whether one alternative is 6 or 7 times more important than another.Therefore, we did not use AHP method in the proposed framework and it is need to study another method overcome AHP method problems; as Fuzzy-ANP method is used in the ***proposed*** framework.

4. Fuzzy Analytic Network Process (Fuzzy-ANP)

Fuzzy-ANP is comprised of fuzzy set theory and Analytical Network Process (ANP).
Analytical Network Process (ANP), a generalization of analytic hierarchy process (AHP), is a multi-criteria assessment tool for decision structuring and analysis which is used widely in Multiple Criteria Decision-Making (MCDM) environment for dealing with complex decision making problems. It provides a general framework to deal with decisions without making assumptions about the independence of higher level elements from lower level elements. The basic idea of the AHP is that the decision-making problem can be decomposed in a linear top-to-bottom form as a hierarchy, where the upper levels are functionally independent from all lower levels, and the elements in each level are also independent. However, many decision-making problems cannot be structured hierarchically, or there would exist strong interactions and dependencies between inter-level and/or intra-level elements [25]. In order to overcome this limitation, Saaty 1996 stated that ANP is a coupling of two parts. The first consists of a control hierarchy or network of criteria and sub-criteria that control the interactions. The second is a network of influences among the elements and clusters. The ANP approach is an extended

version of the AHP approach that can be used to assess a dynamic multi-directional relationship among decision attributes [10].

In many practical cases, the judgments might be uncertain in decision making, due to the subjective nature of judgments, lack of data or incomplete information. Imprecision may arise from a variety of reasons: unquantifiable information, incomplete information, unobtainable information and partial ignorance [25]. The traditional ANP may not reflect human preferences properly and cannot effectively handle problems with such imprecise information when the judgments are unable to provide crisp values that help a decision maker to use non-numerical terms for comparison ratios.

Therefore, we need to express about the comparison ratios as fuzzy numbers in order to deal with the subjective uncertainty and to increase the capabilities of the ANP for weights from uncertain judgments by introducing fuzzy numbers in the pair-wise comparison of the ANP by converting linguistic judgments into fuzzy numbers. Furthermore, there have been attempts to integrate the fuzzy set theory and the ANP for expressing the uncertain preferences in fuzzy group decision making problem [10-13]. Zadeh (1965) pioneered the use of fuzzy set theory to manipulate information and data for expressing the uncertain comparison judgments as a fuzzy numbers [11].

Fuzzy numbers and linguistic variables support decision makers to express the subjective judgments. Therefore, the fuzzy ANP approach is introduced to be a more suitable approach to obtain realistic results. Some researchers have applied the fuzzy ANP based approach to solve complex decision making problems in different areas.

Nihal Erginel and Sevil Şenturk (2011) used fuzzy ANP to rank for three Global Systems for Mobile Communications (GSM) operators in Turkey. In where they identified five main criteria and sub-criteria for each one and can finally realize which criteria and sub-criteria are important for customers and can take improvement action to gain more customers [14]. N. Rezaeiniya, et al., (2014) used fuzzy ANP to locate and rank candidates of greenhouses, and finally, it has significantly increased the efficiency of decision-making process in greenhouse locating [21]. Shen, et al., (2010) propose an innovative model that integrates fuzzy set theory and analytic network process to distinguish strong financial prospect stocks among high book-to-market (B/M) stocks and the practicability of the proposed model is verified by real stocks' data collected from April 2008 to December 2009 in Taiwan [15]. Onut, et al., (2011) employ FANP to identify the qualitative and quantitative evaluation criteria, to define the effects of them on each other, to assess their importance and to choose the most suitable container port [17]. Chen and Yang (2011) used fuzzy ANP to evaluate region agricultural drought risk by Hunan Province agricultural drought in China from 2007 to 2009 [18]. Onüt, et al., (202009) develops a supplier evaluation approach based on (ANP) and the technique for order performance by similarity to ideal solution (TOPSIS) methods to help a telecommunication company in the GSM sector in Turkey under the fuzzy environment [20].

R. P. MOHANTYy, et al., (2005) proposed an application of fuzzy ANP along with fuzzy cost analysis in selecting research and development of projects to be compatible with the company's vision and mission [19]. Kahraman, et al., (2006) proposed an integrated framework based on fuzzy-QFD and a fuzzy optimization model to determine the product technical requirements (PTRs) to be considered in designing a product and finally the coefficients of the objective function were obtained from a fuzzy (ANP) approach [22]. Cheng, et al., (2008) proposed an evaluation model using fuzzy (ANP) approach to measure medical organizational performance and to reduce dependence on human judgments [25].

Dagdeviren, et al., (2008) used the fuzzy ANP approach in measuring the weights of the faulty behavior factors and sub-factors to calculate the FBR which is significant in work system safety [24]. M. Gupta and R. Narain (2014) used a Fuzzy ANP approach, along with the extent analysis to compare the business strategies and select the best one between them (E-Procurement, E-Coordination and E-Commerce) in order to enhance the efficiency of the organization, improve sales performance and better relationships with trade partners and suppliers [23].

Fuzzy set theory, first introduced by Zadeh in 1965, has been developed to meet the objective of solving problems in which descriptions of activities, observations and judgments are by nature subjective, vague and imprecise [16]. The theory can provide numerous methods to represent, in the network, the vagueness and subjective relationships due to incomplete information in many problems. Fuzzy ANP algorithm uses both interdependence and inner dependence of criteria with pairwise comparison matrix. It is constructed by Chang's extent analysis method, which is described in details [26].

Let X={x1, x2,…, xn} be an object set and G={g1, g2,…, gn} be a set of goals. According to the method of Chang's extent analysis, each object is taken and extent analysis for each goal, gi, is performed, respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$M_{gi}^{1}, M_{gi}^{2}, \ldots, M_{gi}^{m} \qquad i=1,2,\ldots,n$

Where M_{gi}^{j} $(j=1,2,\ldots,m)$ are triangular fuzzy numbers (TFNs)
A triangular fuzzy number $\tilde{M}$ is defined as (l, m, u), where $l \leq m \leq u$. The parameters l, m and u respectively, denote the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event. Each triangular fuzzy number has linear representations on its left and right side (Figure. 1) such that its membership function can be defined as the following:

$$\mu_{\tilde{M}}(x)=\begin{cases}(x-l)/(m-l) & l \leq x \leq m,\\ (x-u)/(m-u) & m \leq x \leq u,\\ 0 & otherwise\end{cases}$$

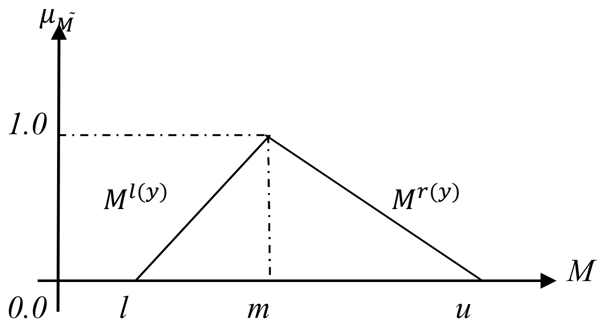

Figure. 1: A triangular fuzzy number, $M^{\sim}$.

The crisp set *(My)* of all elements of the universal set X that belong to the fuzzy set $\tilde{M}$ at least to the degree y ∈[0, 1]:
$\tilde{M} = (M^{l(y)}, M^{r(y)}) = (l + (m - l)\, y,\ u - (u - m)\, y).$
Where *l(y)* denote the left side representation and *r(y)* the right side representation of a fuzzy number.

FANP Algorithm can be summarized as follows:

Step 1: Construct the network to show the interdependencies of the factors and related sub-factors.
Step 2: Construct the pair-wise comparison matrices to calculate local weights of the factors and sub-factors. Where, assigning linguistic terms to the pair-wise comparison matrices by asking which criteria should be emphasized more and how much. The value of fuzzy synthetic extent with respect to the i th object is defined as:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right] \quad Equation\ (1)$$

where $\sum_{j=1}^{m} M_{gi}^{j}$ *represent the fuzzy addition operation of m extent analysis values for a particular matrix such that,*

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j,\ \sum_{j=1}^{m} m_j,\ \sum_{j=1}^{m} u_j\right) \quad Equation\ (2)$$

Get the fuzzy addition operation of M_{gi}^{j} *(j=1,2,...m) values as:*

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right] = \left(\sum_{i=1}^{n} l_i,\ \sum_{i=1}^{n} m_i,\ \sum_{i=1}^{n} u_i\right) \quad Equation\ (3)$$

and then compute the inverse of the vector above as:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right] = \left(\frac{1}{\sum_{i=1}^{n} u_j}, \frac{1}{\sum_{i=1}^{n} m_j}, \frac{1}{\sum_{i=1}^{n} l_j}\right) \quad Equation\ (4)$$

then, the degree of possibility for each convex fuzzy number S2 = (l2, m2, u2) to be greater than other convex fuzzy numbers S1= (l1, m1, u1) is defined as:
V (S2≥S1) = sup [min (μS1(x), μS2(y))]

$$= \begin{cases} 1, & if\ m_2 \geq m_1, \\ 0, & if\ l_1 \geq u_2\ , \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise \end{cases} \quad Equation\ (5)$$

Finally, the non-fuzzy local weights of the factors and sub-factors would be as:

W = (min v (s1 ≥ sj), min v (s2 ≥ sj),…, min v (sn ≥ sj)) Equation (6)

Step 3: Constructing dependence matrix by calculating the inner dependence matrix of each factor regarding the other factors with fuzzy scale and then arranging it into one matrix.
Step 4: Calculating the interdependent weights of the factors by multiplying the local factor weights calculated in step 3 and the dependence matrix calculated in step 4.

Step 5: Calculating the global weights for the sub-factors by multiplying the local sub-factor weights calculated in step 3 and the interdependent weights of the factor to which it belongs calculated in step 5.
Step 6: Getting the ranking of alternatives by multiplying the global weights of sub-criteria and the weights of alternatives for each factor.

5. Proposed Framework for The readiness Assessment

As the nature of the human being, linguistic values can change from person to person. In these circumstances, considering the fuzziness will provide less risky decisions. Therefore, MCDM and linguistic expressions treat with that problems and used to evaluate the alternatives with multi criteria. One of the most important tools of MCDM is the fuzzy approach that is suitable for modeling these linguistic expressions with fuzzy numbers.

This study proposes a practical framework based on fuzzy ANP approach using Chang's extent analysis method to prioritize many solutions for IT innovation in government organizations and the decision-makers can realize which criteria, sub-criteria are important, and which are weak to take improvement action against it. The proposed framework as follow in figure (2):

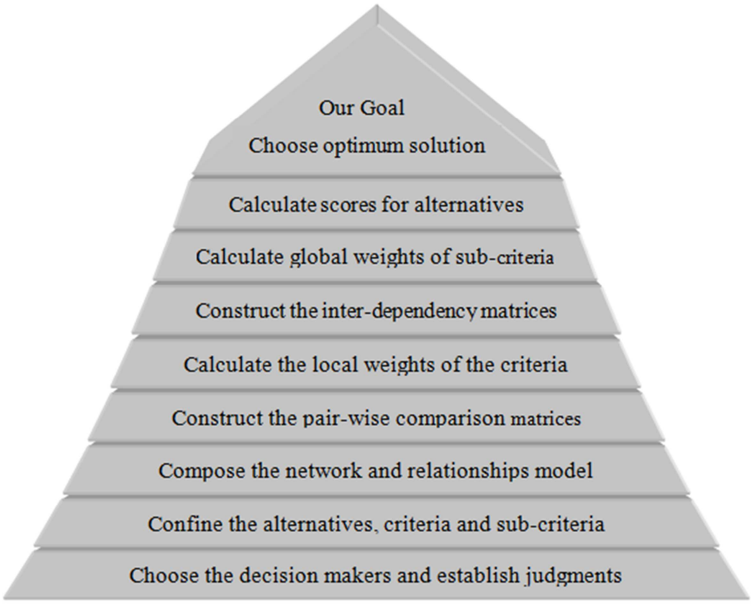

Figure. 2: The flow chart of the 9C proposed framework.

5.1 Choose the decision makers and establish judgments.

Once the decision to implement IT innovation is made, some preparations such as decision makers choosing, team formation, the problem should be stated clearly and decomposed, project goals should be identified and project scope definition would be necessary and must be performed at the beginning of the project, so it is the first and most important step in the framework; because all next steps will be built on it, in where, the top management should describe to the work teams all details about the project. Finally, they pool their judgments in such a way that the group becomes a new 'individual' and behaves like one. So, the aggregated judgments may not reflect any one decision maker's thoughts perfectly [16]. Therefore; they should be experts in analysis and evaluation, cooperative, collective and representative from every department.

5.2 Confine the alternatives, the influencing criteria and sub-criteria.

The decision makers will have to determine the available alternatives and their details to adopt ICT innovation or to solve its problems in the organization.
In addition, gathering all influencing criteria and sub-criteria through direct interviews with the departments' managers and a sample of end users for formulating the questionnaire survey which consists of these criteria.

There are researches employ different models consist of many influencing criteria in innovation process, but in this paper, we will adopt "M.M. Kamal" [27] model for many reasons:

- Comprehensive model is built after comparison of 24 other models adopt IT innovation.
- This model is developed for IT innovation adoption in government sector which is the study interesting.
- This model consists of factors and sub-factors have direct interrelationships with the organization.

Identifying the criteria helps understanding and analyzing the current state of organization in three perspectives (Organizational, Environmental and Technological). Therefore, these criteria represent as opportunities and constraints can facilitate or hinder innovation process.
Finally, grouping these elements into clusters to form the network and identify the relationships between them in next step.
The sub-criteria of three main criteria as blew:

- **Organizational factors (C1):**
    - Organization performance (C11)
    - Staff skills and culture (C12)
    - Organization size (C13)
    - Financial support and capabilities (C14)
    - Top management support and authority (C15)
    - Administrative structure (C16)
    - Laws and regulations (C17)
- **Environmental factors (C2):**
    - Political and social conditions (C21)
    - Competitors (C22)
    - Customer satisfaction (C23)
    - Market knowledge (C24)
    - Stakeholders' participation in decision making (C25)
    - Critical mass (C26)
- **Technological factors (C3):**
    - IT capability (C31)
    - Relative advantage (C32)
    - Compatibility (C33)
    - Complexity in implementation and using (C34)
    - Reliability (C35)

In our study, we concentrate on these three perspectives, and then in future work, we will analyze and study more criteria and more perspectives.

5.3 Compose the network model

Many decision-making problems cannot be structured hierarchically because they involve the interaction and dependence o1f higher level elements on lower level elements [21]. However sub-criteria in the lower level may provide feedback to the criteria in the higher level, also may there is inter dependence among the criteria in the same level. With factors influenced each other, and dependent on each other in the network layer, important degree can use direct comparison or indirect comparison [18]. Therefore, there are three types of relationships among criteria. Direct relationship dependency between two elements may be considered as a regular dependency in a standard hierarchy. Indirect relationship dependency which is not direct between two elements but it flows through third element. Third relationship is interdependencies among criteria which form a mutual effect.

5.4 Construct the pair-wise comparison matrices among all the criteria and sub-criteria.
The criteria are compared with each other assuming that there is no dependency among them. The general question is ‘‘How important is criteria/sub-criteria (A) compared with criteria/sub-criteria (B)?” and the answer is a linguistic scales for relative importance (Table 1).

5.5 Calculate the local weights of the criteria and sub-
criteria according to equations (1 to 6).

5.6 Construct the inter-dependency matrices using pair-wise comparisons made by the experts.
For each of the three criteria, a matrix is formed and relative importance weights are calculated then calculate the interdependent weights of the criteria.

5.7 Calculate the global weights for the sub-criteria
By multiplying the local sub-criteria weight and the interdependent weights of the criteria to which it belongs.

5.8 Calculate the readiness score for each alternative,
compare between them and finally choose the optimum one.

6. Case Study

The proposed model has been applied in Ministry of Higher Education in Egypt to measure the ministry’s readiness to implement an IT innovation. The ministry has recently decided to implement IT innovation in order to improve efficiency and performance. The ministry has about 1100 employees and composed of five different functional departments. Each department has particular information system with these drawbacks:

- Fragmentation of resources and insufficient exchange of client’s data.
- Many e-services with poor performance and Data Scalability.
- Redundancy of data and applications.
- Obsolete technologies and legacy’ software.
- Complexity in auditing and logging for millions of transactions daily.

Therefore, ministry’s top management thinks to solve those drawbacks but there are many solutions, which one is the best, and what is the readiness degree of the ministry to adopt one of them with existence many factors can affect on the decision so the proposed readiness assessment framework is ready to be applied.

Step 1: Choose the decision makers from top management of the ministry as 1 first under secretary of the ministry, 3 administrators of the central managements, 5 administrators of the general managements and 2IT consultants in information systems implementations. Prepare the documents and questionnaires required to the project, and analyze, study and discuss the details of the problem and goal for the committee.

Step 2: The committee suggested that they have three alternatives to overcome current obstacles: current technology modifications (A1), adopt mobile technology and work from home (A2), and adopt cloud computing (A3). These alternatives will be in relation with all assessment criteria in the network because these criteria have an effect in all these alternatives.

Step 3: They formed the network model and relationships between criteria and sub-criteria as in figure (3).

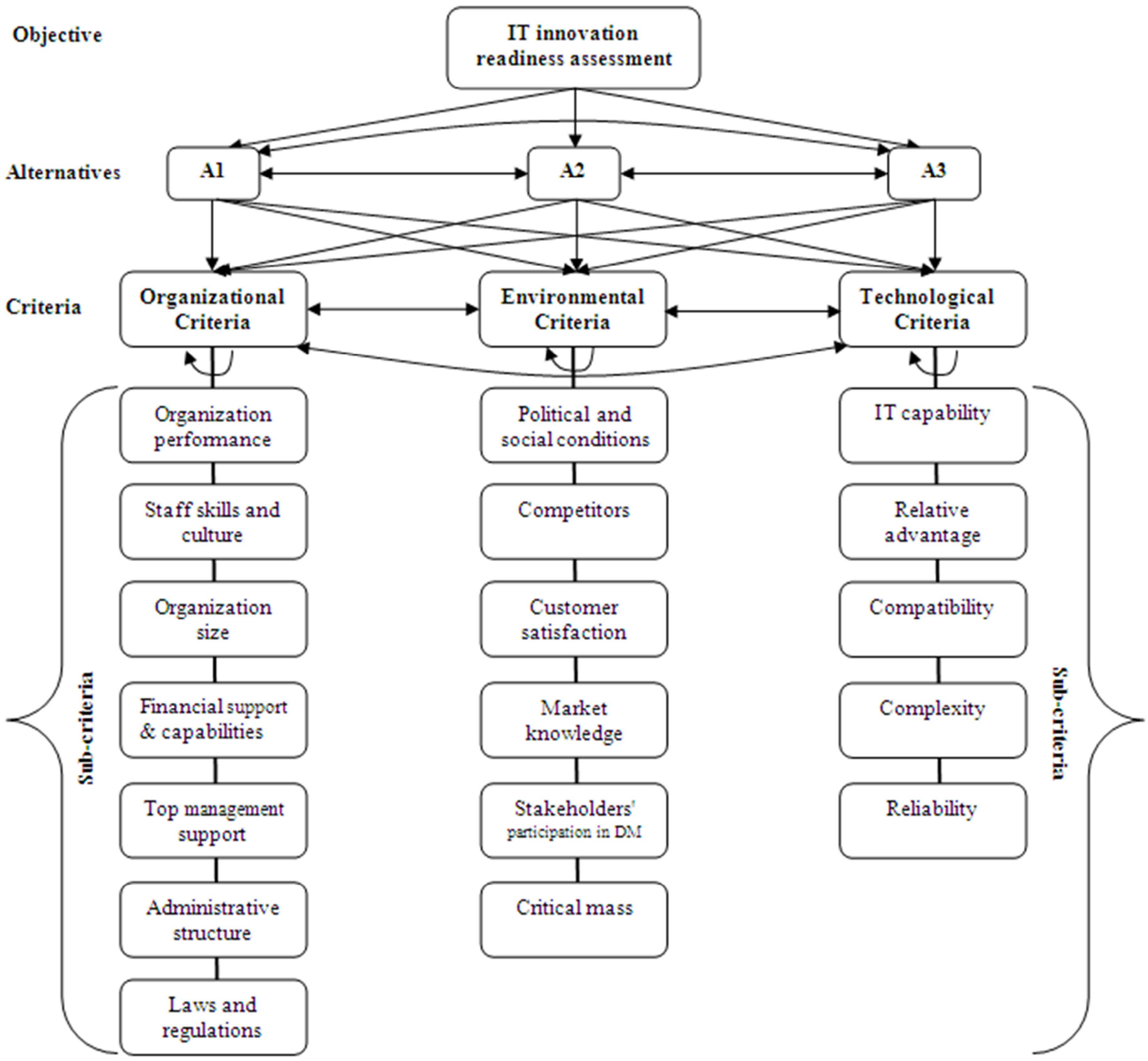

Figure. 3: The network model and relationships between criteria and sub-criteria.

Step 4: For each of three alternatives, each member in the committee was separately asked to compare the criteria with each other assuming that there is no dependency among them and assign variables to describe the preferences by means of linguistic scales in table 6, then compare their judgments with each other to discuss the cases where the assigned variables were far from each other, finally they were asked to refine these judgments. The pair-wise comparisons for the sub-criteria are also performed belonging to each main criteria to determine their local weights.

Table 6 Linguistic Scales for Relative Importance

Linguistic scales for relative importance	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Just equal	(1,1,1)	(1,1,1)
Equally important	(0.5, 1, 1.5)	(0.67,1,2)
Weakly more important	(1, 1.5, 2)	(0.5,0.67,1)
Strongly more important	(1.5, 2, 2.5)	(0.4,0.5,0.67)
Very strongly more important	(2,2.5,3)	(0.33,0.4,0.5)
Absolutely more important	(2.5,3,3.5)	(0.29,0.33,0.4)

Step 5: The local weights of the criteria are determined with respect to three alternatives using pair-wise comparisons performed by the experts based on equations (1 to 6) in section 4. And the results are illustrated in table 8.

Also, the local weights of the sub-criteria are calculated and all results are illustrated in tables (9, 10 and 11).

Table 7 Linguistic Variables to Measure Sub-factors

Seq	Linguistic variables	Fuzzy scale
1	Very low	(0, 0, 25)
2	Low	(0, 25, 50)
3	Medium	(25, 50, 75)
4	High	(50, 75, 100)
5	Very high	(75, 100, 100)

Table 8 Pair-wise Comparisons and Local Weights of Criteria with Respect to three Alternatives A1, A2 and A3

Criteria	C1	C2	C3	Local Wait
A1				
C1	(1,1,1)	(0.5,0.67,1)	(1,1.5,2)	0.34
C2	(1,1.5,2)	(1,1,1)	(1.5,2,2.5)	0.56
C3	(0.5,0.67,1)	(0.4,0.5,0.67)	(1,1,1)	0.10
A2				
C1	(1,1,1)	(2,2.5,3)	(1.5,2,2.5)	0.75
C2	(0.33,0.4,0.5)	(1,1,1)	(0.67,1,2)	0.16
C3	(0.4,0.5,0.67)	(0.5,1,1.5)	(1,1,1)	0.09
A3				
C1	(1,1,1)	(0.5,1,1.5)	(0.5,0.67,1)	0.17
C2	(0.67,1,2)	(1,1,1)	(0.33,0.4,0.5)	0.16
C3	(1,1.5,2)	(2,2.5,3)	(1,1,1)	0.67

Table 9 Pair-wise Comparisons and Local Weights for the Sub-criteria of Governmental (C1)

Sub-criteria	C11	C12	C13	C14	C15	C16	C17	Local Wait
C11	(1,1,1)	(0.29,0.33,0.4)	(0.5,1,1.5)	(0.4,0.5,0.67)	(0.67,1,2)	(0.5,0.67,1)	(2,2.5,3)	0.12
C12	(2.5,3,3.5)	(1,1,1)	(0.5,0.67,1)	(0.67,1,2)	(0.67,1,2)	(1.5,2,2.5)	(1,1.5,2)	0.18
C13	(0.67,1,2)	(1,1.5,2)	(1,1,1)	(0.29,0.33,0.4)	(0.5,0.67,1)	(0.5,0.67,1)	(1.5,2,2.5)	0.13
C14	(1.5,2,2.5)	(0.5,1,1.5)	(2.5,3,3.5)	(1,1,1)	(1,1.5,2)	(0.5,0.67,1)	(0.4,0.5,0.67)	0.17
C15	(0.5,1,1.5)	(0.5,1,1.5)	(1,1.5,2)	(0.5,0.67,1)	(1,1,1)	(0.67,1,2)	(2,2.5,3)	0.16
C16	(1,1.5,2)	(0.4,0.5,0.67)	(1,1.5,2)	(1,1.5,2)	(0.5,1,1.5)	(1,1,1)	(1.5,2,2.5)	0.16
C17	(0.33,0.4,0.5)	(0.5,0.67,1)	(0.4,0.5,0.67)	(1.5,2,2.5)	(0.33,0.4,0.5)	(0.4,0.5,0.67)	(1,1,1)	0.08

Table 10 Pair-wise Comparisons and Local Weights for the Sub-criteria of Environmental (C2)

Sub-criteria	C21	C22	C23	C24	C25	C26	Local Wait
C21	(1,1,1)	(0.4,0.5,0.67)	(0.33,0.4,0.5)	(0.67,1,2)	(0.5,0.67,1)	(0.67,1,2)	0.09
C22	(1.5,2,2.5)	(1,1,1)	(0.5,0.67,1)	(1,1.5,2)	(1.5,2,2.5)	(2,2.5,3)	0.28
C23	(2,2.5,3)	(1,1.5,2)	(1,1,1)	(1.5,2,2.5)	(2,2.5,3)	(1.5,2,2.5)	0.33
C24	(0.5,1,1.5)	(0.5,0.67,1)	(0.4,0.5,0.67)	(1,1,1)	(0.4,0.5,0.67)	(0.5,0.67,1)	0.04
C25	(1,1.5,2)	(0.4,0.5,0.67)	(0.33,0.4,0.5)	(1.5,2,2.5)	(1,1,1)	(0.5,1,1.5)	0.15
C26	(0.5,1,1.5)	(0.33,0.4,0.5)	(0.4,0.5,0.67)	(1,1.5,2)	(0.67,1,2)	(1,1,1)	0.12

Table 11 Pair-wise Comparisons and Local Weights for the Sub-criteria of Technological (C3)

Sub-criteria	C31	C32	C33	C34	C35	Local Wait
C31	(1,1,1)	(0.5,1,1.5)	(1,1.5,2)	(1.5,2,2.5)	(0.5,1,1.5)	0.25
C32	(0.67,1,2)	(1,1,1)	(0.5,0.67,1)	(1,1.5,2)	(0.5,0.67,1)	0.19
C33	(0.5,0.67,1)	(1,1.5,2)	(1,1,1)	(1.5,2,2.5)	(1,1.5,2)	0.25
C34	(0.4,0.5,0.67)	(0.5,0.67,1)	(0.4,0.5,0.67)	(1,1,1)	(0.4,0.5,0.67)	0.08
C35	(0.67,1,2)	(1,1.5,2)	(0.5,0.67,1)	(1.5,2,2.5)	(1,1,1)	0.24

Step 6: Construct the inter-dependency matrices using pair-wise comparisons for each criteria as alone and all results are illustrated in tables (12, 13 and 14), finally, the dependence matrix is formed based on last three tables and the result is illustrated in table 15.

Table 12 Inter-dependency matrix of the criteria based on C1

C1	C2	C3	Relative importance weight
C2	(1,1,1)	(0.5,0.67,1)	0.32
C3	(1,1.5,2)	(1,1,1)	0.68

Table 13 Inter-dependency matrix of the criteria based on C2

C2	C1	C3	Relative importance weight
C1	(1,1,1)	(0.5,1,1.5)	0.50
C3	(0.67,1,2)	(1,1,1)	0.50

Table 14 Inter-dependency matrix of the criteria based on C3

C3	C1	C2	Relative importance weight
C1	(1,1,1)	(1,1.5,2)	0.68
C2	(0.5,0.67,1)	(1,1,1)	0.32

Table 15 Dependence matrix of the criteria

Criteria	C1	C2	C3
C1	1	0.50	0.68
C2	0.32	1	0.32
C3	0.68	0.50	1

Step 7: Calculate the interdependent weights of the three criteria with respect to three alternatives using multiplying the local weights (table 8) by dependence matrix (table 15) then the result is illustrated in table 16.

Table 16 Interdependent weights of the three criteria

	A1	A2	A3
C1	0.3440	0.4456	0.3528
C2	0.3504	0.2144	0.2144
C3	0.3056	0.3400	0.4328

Step 8: Calculating the global weights for the sub-criteria by multiplying the local sub-criteria weight tables (9, 10 and 11) and the interdependent weights of the criteria to which it belongs table (16) then the results are illustrated in table 17.

Step 9: Calculating the score of readiness for each of three alternatives and the results are illustrated in table 18.

Table 17 Dependence matrix of the criteria

		A1		A2		A3	
		Interdependent Weights	Global Weights	Interdependent Weights	Global Weights	Interdependent Weights	Global Weights
C1	C11	0.3440	0.0408	0.4456	0.0540	0.3528	0.0424
	C12		0.0612		0.0810		0.0635
	C13		0.0442		0.0585		0.0459
	C14		0.0578		0.0765		0.0600
	C15		0.0544		0.0720		0.0565
	C16		0.0544		0.0720		0.0565
	C17		0.0272		0.0360		0.0282
C2	C21	0.3504	0.0315	0.2144	0.0189	0.2144	0.0193
	C22		0.0980		0.0588		0.0599
	C23		0.1155		0.0693		0.0706
	C24		0.0140		0.0084		0.0086
	C25		0.0525		0.0315		0.0321
	C26		0.0420		0.0252		0.0257
C3	C31	0.3056	0.0775	0.3400	0.0850	0.4328	0.1082
	C32		0.0589		0.0646		0.0823
	C33		0.0775		0.0850		0.1082
	C34		0.0248		0.0272		0.0346
	C35		0.0744		0.0816		0.1039

Table 18 Readiness scores for the three alternatives

	Sub-Criteria	Ling-Value	A1	A2	A3
C1	C11	75	3.0600	4.0500	3.1800
	C12	50	3.0600	4.0500	3.1750
	C13	75	3.3150	4.3875	3.4425
	C14	75	4.3350	5.7375	4.5000
	C15	50	2.7200	3.6000	2.8250
	C16	50	2.7200	3.6000	2.8250
	C17	25	0.6800	0.9000	0.7050
C2	C21	50	1.5750	0.9450	0.9650
	C22	50	4.9000	2.9400	2.9950
	C23	25	2.8875	1.7325	1.7650
	C24	75	1.0500	0.6300	0.6450
	C25	25	1.3125	0.7875	0.8025
	C26	50	2.1000	1.2600	1.2850
C3	C31	100	7.7500	8.5000	10.8200
	C32	75	4.4175	4.8450	6.1725
	C33	75	5.8125	6.3750	8.1150
	C34	75	1.8600	2.0400	2.5950
	C35	100	7.4400	8.1600	10.3900
Readiness score			60.9950	64.5400	67.2025

According to the final readiness scores, the results show that the third alternative realized the higher readiness score 67.2025, then the second alternative, and finally the first solution realized the lower readiness score. Therefore, the third solution is the optimum solution for the Ministry of Higher Education.

In addition, we note that, C31 and C35 have been defined very well. However, major difficulties can be seen to be related to C17, C24 and C25. Thus, the ministry should plan to perform a number of short-term procedures in order to improve the reception to adopt new solution.

For instance, it is strongly needed to be aware of the market state by arranging continuous seminars and symposiums for the employees to make them up to date and familiarize with all knowledge about the market.

The improvements achieved on readiness levels in preliminary phase assure a greater degree of adopting success for the new solution and prevent encountering major challenges later at the implementation phase.

7. Comparison between final results in AHP and Fuzzy-ANP

The results in proposed framework, used ANP method, indicates three important indicators; interconnections between criteria, sub-criteria and alternatives as in figure. 3, sorting the alternatives (A3, A2 and A1) and extent of the organization readiness for each sub-criteria as (C31 and C35 have been defined very well but major difficulties can be seen to be related to C17, C24 and C25).

But using AHP method, the results indicate only sorting the alternatives (A1, A2 and A3) and it does not take into account the interconnections between criteria, sub-criteria and alternatives.

Therefore, the proposed method is useful in complex projects as (IT projects) have network and dependencies between their criteria, sub-criteria and alternatives. But AHP is useful in simple projects that: criteria do not affect alternatives, criteria do not depend on each other and alternatives do not depend on each other.

Finally, a proposed framework allows governmental organizations to deal with the interconnections (dependence and feedback) between criteria of complex structure in IT adoption decision making process. Since most of these criteria conflict each other, interrelated and depending on each other. Also, network model with dependence and feedback improves the priorities derived from judgments and makes prediction much more accurate. In addition, the decomposition of project's criteria into its sub-criteria and calculating the readiness for each item is a good indicator for decision makers to identify the strength and weakness of the organization before the project initiation then reengineering the organization's processes and structure and refinement the weakness.

8. Conclusion and future work

In this study, the fuzzy Analytic Network Process approach is used to analyze and to solve a multi-criteria IT innovation adoption problem. The fuzzy ANP approach has been applied to different kinds of MCDM problems in the literature, but not to multi-criteria IT innovation adoption problems. The determination of the criteria weights and evaluation of the IT innovation solutions are not easy tasks. Therefore, the concept of fuzziness supports decision makers to make decisions that are more flexible in vagueness environments.

Hence, Fuzzy ANP approach is utilized in order to propose a new practical framework to solve the IT innovation adoption problem in governmental sector, which should determine the best solution among many alternatives. The proposed framework inspected the three alternatives with respect to three criteria namely; Organizational, Environmental, and Technical with their sub-criteria. The interdependencies between criteria are also taking into account within the proposed approach.As a result of real example was investigated at Ministry of Higher Education in Egypt, it is seen that the third solution outperforms the others The results illustrated that it is too early to start adoption for any new modification for this organization. It was suggested that the ministry is better off doing some preliminary preparation to increase the receptivity of the personnel first prior to initiating the IT innovation adoption project. It should be noted that the cost of using the proposed model is negligible for the ministry compared to the huge cost of starting an adoption any of IT innovation's solutions and even more considerable cost of a failed adoption system.In further studies, identifying a new comprehensive (before, during and after adoption process) framework for adopting the optimal solution of IT innovation in governmental sector and how to integrate between it and this proposed framework introduced in this study.

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