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DEVELOPING AN INTEGRATED RISK MANAGEMENT SYSTEM FOR EVALUATING PPP PROJECTS IN LIBYA

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ABSTRACT

Libya is one of the many countries which have experienced economic problems, making it difficult to procure infrastructure projects like bridges, water plants, airports and roads. Moreover, the limited financing for the expansion and operation of infrastructure project is pushing authorities to draw private investment and enter public-private relationships. The aim of this paper is to assess the serviceability and impact of the socio-economic environment through key performance indicators (KPIs), which represent influential key factors in the private sector with regard to developing the PPP infrastructure projects. This paper presents a framework for the appraisal of PPP infrastructure projects in the context of risk assessment of the integrated system named RAA3P; it integrates several techniques, such as fault tree, neural networks, and the analytic network process. This system aims to ensure sustainable satisfaction of project's returns that are essential for the development of PPP infrastructure projects in Libya. The paper also considers the different risks that the country may face in the environment of uncertainty which exist in the lifecycle process of these projects. In addition, it predicts the internal rate of return (IRR) of business model that is associated with the funding methods.

KEYWORDS: Fault tree, neural networks, analytic network process, decision support system.

1. INTRODUCTION

Infrastructure risk management is at the core of public private partnerships (PPPs) and include opportunities that can bring potential benefits, but, at the same time, they may give rise to many risks. Integrating risk management practices into the projects to align the business environment with the benefits strategy by measuring and mitigating risk exposure, and making informed decisions to avoid, minimise, transfer or accept such risks can contribute to optimal return for stakeholders.

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Therefore, it is important to develop a system that involves a risk evaluation model to evaluate the probable adverse effects in various project phases using key performance indicators (KPIs) to assess the serviceability and socio-economic. Project-specific evaluations can include metrics related to probability of risk occurrence and financial viability, as the implication of specific risks will vary from one project to another, depending upon the project attributes; while the road projects may have high development and high market risks, the energy projects have low operational and market risks and high debt servicing risk.

2. LITERATURE REVIEW

A crucial review of the literature published on diverse techniques was conducted to study the risk assessment models in PPP Infrastructure projects over the last 16 years. It was found that many models have been developed for infrastructure procurement in light of quantitative methodologies which have been proposed for project risk assessment. However, these traditional methodologies cannot sufficiently gauge the risk variables and their interrelationships. They attempt to estimate contingencies/provisional sum model qualitatively and lack the joint effects of financial and non-financial variables. The commonly employed techniques for conducting risk analysis are: probabilistic risk assessment; decision/event/Fault tree analysis; sensitivity analysis; Monte Carlo simulation; and multi-criteria decision analysis (MCDA) such as analytic hierarchy process (AHP), cost benefit analysis, bays nets, and fuzzy logic.

With the expanding interest in infrastructure and the enormous cost of development and activity, governments are seeking private funds to finance the general population projects and deliver the subsequent services [1]. However, this involves many risks.

Risk assessment technique using fuzzy analytical hierarchy process (AHP) was developed to simulate the unclearness of human judgment and to enhance the accuracy of risk assessment [2].

AHP is implemented within a multi-criteria decision making (MCDM) framework for the risk assessment of international construction projects. It calculates the overall risk level of each project by multiplying the relative impact with the relative probability for each risk and then adding up the scores [3]. It is used in developing a multi-criteria risk assessment model for constructing joint ventures so that the overall utility can be obtained by considering the objectives and risk factors. It yields a utility index for a given set of alternatives [4].

The risk assessment model of binding mode, which combines the AHP and fuzzy comprehensive evaluation method, was developed [5] to change the characterization problem into the quantitative problem. It was applied in a new type of public project investment and financing model named BT.

They developed an evaluation index of the expressway construction phase risks using the back propagation artificial neural network technique [6].

PPP financial models are based upon the most preferred financial input and output indicators by comparing three PPP financial models that are used for project evaluation and negotiation [7].

Model of the risk assessment of PPP for airport infrastructure in Indonesia was proposed [8].

The proposed model was assessed for fund generation options and the equitable bounds were calculated for ensured incomes for the project's sponsor under risks and uncertainty [9].

After conducting this overview of risk assessment models of PPPs, it has been found that:

1. Most of the research on PPPs has been conducted from the perspective of the public sector or the contracting entities, but do not probe the perceptions of the financiers. Also, very rare risks can be seized in decision making models, and the common factor in the existing risk assessment models is that the tools can only be used for qualitative risk analysis in project management, which results in generation of a risk register.
2. The findings from the literature review concluded that the risk assessment approaches were not involved in the financing scheme of PPP projects. There is a lack of carrying out the project's structural studies using tools such as key

performance indicators, which would assess the different impacts of a risk on the project's objectives.

3. There is a need to further develop the risk assessment to capture the challenges associated with the knowledge dimension in PPPs to manage different risk strategies in a proactive manner.
4. Although many authors recommended the use of decision support system, which is a common technique for conducting PPP studies that have been justified, they lack the concept of extending the practical model of PPP's risks to consider the financial viability as a probability of risk occurrence and its impact on key performance indicators.

There is a need to further develop the risk assessment so as to capture these challenges linked to the knowledge area of PPPs infrastructure projects, as well as to manage the different risk strategies in a proactive manner, taking into consideration the analysis of PPP appraisals that require an understanding of the socio-economic benefits, and sustainable serviceability to ensure optimal project outcomes. Therefore, the RAA3P system presented in this paper attempts to provide a systematic framework procedure for the appraisal mechanism of PPP infrastructure projects using a broad approach to examine the KPI-based risk evaluation. It also aims to overcome the gap in the previous studies, which do not link the relationship between models of risk assessment and the most financial variables that affect decision making, in order to audit the PPP structure and maintain the target returns.

3. PROPOSED FRAMEWORK

The proposed framework includes a procedure that identifies and prioritizes risks encountered from different aspects during the implementation of PPP projects in order to contribute to the development of these types of projects through the combination of probabilistic and artificial intelligence techniques that would allow assessing a PPP infrastructure project objectively by considering all its aspects.

This framework utilizes the fault tree analysis (FTA) technique to quantify the probability of risk occurrence. Next, it quantifies the internal rate of project's return using a designated prediction model, employing the processes of analysing and evaluating returns that influence risk variables using artificial neural networks (ANN). Based on the priority of alternative findings, an analytical network process (ANP) model has been established to support the decision making of stakeholders. The decision-making process can be broken down as follows: identifying all the possible alternatives, and assessing the status of risks using key performance indicators (KPIs). This is a principal challenge in any decision-making processes during the evaluation phase as it requires managers to have complete knowledge of all influencing events and their probabilities.

To achieve the main objectives of the study, the following sub-objectives were carried out:

1. Addressing the specific risks associated with a project and quantifying their levels to explore which risk is significant from the perspective of the private sector and according to the probability of occurrence of unforeseeable events that are triggered by risk variables. This covers both general risks and specific risks throughout the different phases of the project’s life cycle.
2. Structuring a quantification model to incorporate the likelihood of risks associated with PPP projects and the financial viability of the project that is measured by the equity “IRR”. The finance scheme should, however, vary in accordance with the risks assumed by the private sector and those shared between the government and the private sector. An adopted mechanism is established to ensure both effective risk management and the project's financial viability for revenue of PPP projects in Libya.
3. Developing a methodology that supports decision making based on the assessment of key performance indicators (KPIs) of PPP projects. This uses a hybrid technique for the analysis of integrity risks based on socio-economic impact assessment and the financial evaluation criteria for developing the finance scheme into a unified analysis process, in order to mitigate project risks and achieve maximum benefits.
4. Undertaking a case study of a toll-road facility, this is typical of most PPP projects in Libya, in order to demonstrate the use of the presented system. Projects will be

tested for their underlying economic value before being considered for investment to validate the proposed framework, which can provide significant insight into the structuring of the PPP scheme.

The presented framework provides project managers with helpful tools to perform risk assessment of PPP infrastructure projects. While it furthers the adopted financial scheme and key performance indicators, it is based on a hybrid technique in a developed system for risk assessment and appraisal of PPP infrastructure projects. The framework is named RAA3P. The system tackles the uncertainty and inaccuracy inherent in human decisions. Figure 1 illustrates a flow chart of the proposed RAA3P framework. The data flows through the system have been developed using graphical user interfaces (GUI) MATLAB.

4. SYSTEM ARCHITECTURE

A new integrated system, named RAA3P, incorporates a different analytical technique that combines probability of risk occurrence, project-specific financial factors, and ranking the alternatives of decision. The first technique is the “fault tree” method for accounting the probability of risk occurrence. The second technique uses a spreadsheet application for evaluation of financial variables to guide the user through inputs process of the “artificial neural network” for predicting the project’s internal rate of return (IRR). The third technique is the “analytical network process” for decision analysis, which validates the output for the revising of PPP schemes.

RAA3P system is considered an integrated method that uses artificial intelligence in construction management, based on probabilistic, prediction, and deductive reasoning in dealing with an uncertain environment associated with PPP infrastructure projects. It estimates the probability of risk occurrence from the perspective of the private sector and identifies alternatives for the decision as well as effectiveness of the risk-mitigating measures that are helpful for auditing the financial scheme of such class of projects to achieve the project's planned IRR.

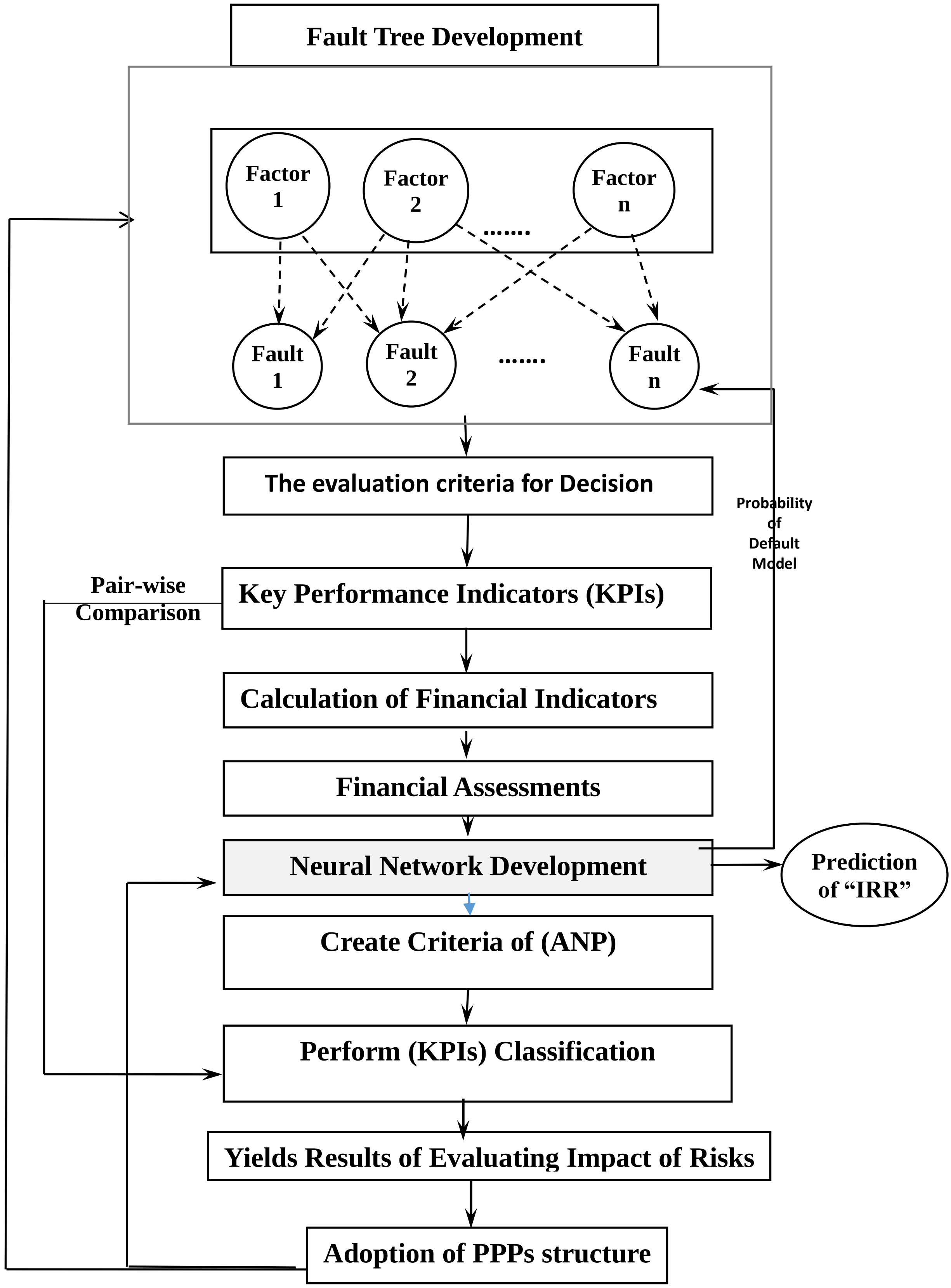


Fig. 1. Flowchart of the Proposed Methodology.

5. RAA3P SPECIFICATION AND DESIGN

The development of RAA3P framework was carried out in five main steps: summarizing and analysing quantitative data, probabilistic modelling of risk using fault tree analysis (FTA) technique, using the prediction model for project revenues that involve the processes of financial analysing, and evaluating risk-affected financial variables using artificial neural network (ANN). Based on the KPIs, the analytical network process (ANP) model was finally established to prioritize the alternatives for auditing the PPP structure in order to satisfy the target rate of project’s returns. The details of the abovementioned phases have been described in the next subsections.

5.1 Risk Identifications

After considering the lessons learnt from the previous PPP projects, this study formulated a questionnaire to gather opinions from risk-management practitioners in Libya’s PPP projects. Several in-depth interviews were conducted, which included managers who had acquired first-hand experience in applying PPP infrastructure projects in Libya as project managers, risk experts, and project team members. The questionnaire survey was supervised to gather data and was drafted relative to the study’s objectives, the research literature and the hypotheses with the involvement of project executives to identify the risk variables which affect infrastructure PPP projects. Furthermore, descriptive statistics were employed for data analysis in order to summarize risk variables via the statistical package for social scientific research (SPSS) software. The following aspects of current practices in risk management in Libya's PPP assignments were examined:

- Identification of major risks in PPP infrastructure projects;
- Frequency of occurrence assessed by respondents for each risk factor;
- Risk rank of each risk variable that was assessed by a given respondent.

The questionnaire adopted in the interviews comprised of two sections. The first section was centred on the organizational experience throughout the frequency of risk occurrence, and its recording. The second section targeted the utilization of project's key performance indicators that evaluate the PPP projects and their assumptions in the context of the risk management process. Answers for segments 1 and 2 were solicited on the 5-point "Likert scale". The analysis showed that these risks were mainly political risks, i.e. legislative changes, project approval and permit, political opposition, and reliability and creditworthiness of Libyan entities. Furthermore, it revealed twenty-one risks that are most associated with infrastructure projects in Libya. These were considered in the analysis done through the proposed system in this paper, as shown in Table 1. These identified risk factors were comprehensively analysed to determine their causes and attributes, whereby applicable measures to mitigate them could be suggested.

Table 1. Risks encountered in the context of PPPs Infrastructure projects.

No.	Risk Code	Risk Factor	Mean of Occurrence Frequency	Mean of Effect Degree	Risk-index Score (RI)
1	P1	Corruption-Market distortion	0.652	0.705	0.4857
2	P2	Political instability risks	0.629	0.743	0.4767
3	P3	Termination of concession	0.590	0.729	0.4419
4	I1	Non availability Site risk	0.567	0.724	0.4324
5	I2	Project Completion Risk	0.595	0.686	0.4276
6	I3	Design changes	0.581	0.705	0.4252
7	I4	Cost and schedule overruns	0.576	0.700	0.4195
8	I5	Geotechnical risks	0.562	0.724	0.4167
9	CR1	Inappropriate Concession period Risk	0.562	0.686	0.3938
10	CR2	Difficulties in resolving disputes	0.586	0.652	0.3938
11	CR3	Renegotiated under duress	0.365	0.369	0.4419
12	CR4	Operation and maintenance Risks	0.567	0.587	0.4324
13	E1	Currency Foreign exchange rate variations	0.629	0.654	0.4276
14	E2	Changes in taxation	0.590	0.754	0.4252
15	E3	Fluctuation of interest rate	0.567	0.469	0.4195
16	E4	Refinancing Risk	0.595	0.743	0.4419
17	E5	Demand and revenue Risks	0.581	0.729	0.365
18	E6	Debt servicing risk (difficulties) in debt-servicing	0.629	0.724	0.547
19	O1	Law Enforcement Risk	0.698	0.686	0.635
20	O2	Regulatory risk	0.635	0.700	0.584
21	O3	Force Majeure	0.456		0.591

5.2 Probabilistic Modelling of Risks

Fault tree is a technique for quantitatively assessing risks of all combinations of undesirable events in PPP-specific risks in an infrastructure project environment in Libya that could lead to a risk event. It could be captured via a fault tree approach by computing the probability of undesirable risk events given the probabilities for the different basic events. The modelling of probabilistic composition of a sequence of events, which brings about the top event, have been developed for all the twenty-one risks, where each risk category model involves one or more individual, basic risk events with its probability of occurrence. The risk tree models can be re-organized by the user of the presented system in this paper to match the project under assessment with regard to the various factors influencing risk events and their inter-relationships which are represented through a set of Boolean logic gates. The failure probability of an output event from two or more independent input events combined by a Boolean OR gate was calculated using Eq. (1) whereas Boolean AND gate was calculated using Eq. (2) as reported [10-11].

$$P(A_0) = 1 - \prod_{i=1}^{n} \{1 - P(A_i)\} \quad (1)$$

$$P(A_0) = \prod_{i=1}^{n} P(A_i) \quad (2)$$

Where A_0 is the top event and A_i is the input event

5.3 Features of Artificial Neural Network

Neural networks are generally applied to handle different issues of prediction in the construction sector. In this paper, an artificial neural network (ANN) model was used to predict the internal rate of return (IRR) for infrastructure PPP projects. It utilized a typical supply forward neural network with a regular back propagation learning algorithm to train the model. This model is used to conduct a prediction of a financial estimator, such as the net present value (NPV), the internal rate of return (IRR), in addition to the calculations conducted using (MS Excel) spread sheet wherein all relevant impacts and parameters necessary for the attributes of financial factors are entered.

For the present study, fifteen financial factors were considered as the input nodes for the neural network which consisted of input layer, one hidden layer, and one output layer representing the IRR percentage. Table 2 lists the most influencing rate of return (IRR) attributes, which include perceptions about profitability, debt finance, organizational financial competence, loan payback period in terms of familiarity with the PPP project. The NN signal type was developed in a discrete manner over time, and the neuron's transfer function was used to convert the neuron's activation level to an output signal for the processing of signals.

Table 2. Rate of Return (IRR) Attributes of PPP Projects.

ID	Factor	Value Range
X1	Primary Investment, in dollar volume	Maximum=1000^{12} Minimum=1000^{3}
X2	Leverage Debt-to-Equity (DE)	High=1 Medium=0.5 Low=0
X3	Awarded Concession period	Good=1 Medium=0.5 Bad=0
X4	Expected Revenues (Equ)	Dollars ($)
X5	Net Cash flow XLS	Dollars ($)
X6	(WACC) Discount rate (Equ)	Percentage
X7	Inflation rate	High=0 Medium=0.5 Low=1
X8	Borrowing interest Expense	High=0 Medium=0.5 Low=1
X9	Borrowing Income Taxes	High=0 Medium=0.5 Low=1
X10	NPV of contract(XLS)	High=1 Medium=0.5 Low=0
X11	Payback period(XLS)	High=0 Medium=0.5 Low=1
X12	Profitability Index	High=1 Medium=0.5 Low=0
X13	Construction period	High=0 Medium=0.5 Low=1
X14	Operation period	High=1 Medium=0.5 Low=0
X15	Debt Service coverage ratio (DCR)	High=1 Medium=0.5 Low=0

5.4. Architecture of the ANP Network

Based on the risk structure and key performance financial indicators, the next step was a logical-deductive approach to prioritize the alternatives that can influence decision making. The third model presented in this paper is the analytical network process model, which is used to assess risks in the context of the KPIs, which were developed from the literature review, group discussion, and questionnaire survey. Four different control criteria were selected for assessing the aspects such as economic, financial sustainability, social, and serviceability, as shown in Table 3. The combination of risks as well as control criteria in a composite assessment was developed to make it a powerful tool for providing adequate performance measurement.

Table 3. Key Performance of PPPs Project Appraisal.

No	Criterion	Sub-criteria
1	Economic	1. Establishment of efficient environmental regulation systems. 2. Reducing government budget deficit by alternative revenue and funding sources 3. Cost reduction due to competition (construction and operating costs). 4. Degree of risk transfer to government. 5. Leverage economic development by securing investment resources in mixed-use developments.
2	Financial sustainability	1. Leverage of debt/equity financing. 2. Revenue guarantees. 3. Acceptable tariff levels. 4. Low construction costs. 5. Forecasts of future demands.
3	Serviceability	1. Assessment of assets condition 2. Effectiveness of cost-benefit 3. Prevention of bureaucratization (downsizing of government operations). 4. Resource utilization. 5. Improving operational efficiency
4	Social	1. Infrastructure development (Increase in service coverage to specific areas). 2. Improvement of land property value. 3. Introduction of advanced technology (allow access to emerging technologies). 4. Enhance and protect the environment. 5. Create a strong team of local partners, highly qualified professionals in engineering skills.

ANP model consists of a systematic process to enhance the confidence that decisions will be upheld via multiple alternatives. It deals with both quantitative and qualitative factors under multiple control criteria. This model was developed to capture the potential impact of imposed risks in the context of KPI management. The proposed model adopts the ANP method, which was selected as a multi-criteria decision model due to the interaction between the criteria and KPI in order to classify the decision model into meaningful network and weight decision elements, which were organized as goals, objectives and alternatives [12].

It was analysed according to each criterion and then synthesized by weighting with these priorities of the "control" criteria belonging to a model, as can be seen in clusters and elements in the benefits sub-model from Fig. 2.

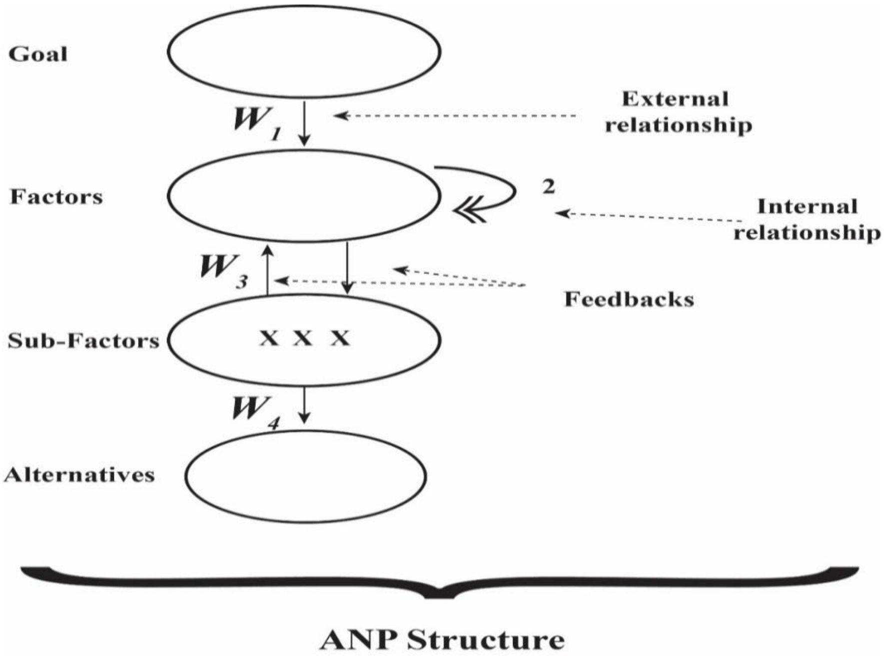


Fig. 2. Generic Representation of ANP Structure.

6. RAA3P IMPLEMENTATION

Implementation of RAA3P system will result in the competency of PPP structure and lead to its operational and investment efficiency. An actual case-study of the Tripoli and Benghazi Toll Road (TBTR) was selected to demonstrate the potential of utilizing RAA3P system in developing the internal rate of return of a PPP project. The case study revealed the capability of RAA3P to develop optimum rate of return that suits the project's parties, while considering the assessed risks involved. Three processes were utilized in the RAA3P system: First, the risk probability of occurrence was done using the fault tree method (FTA). Second, the prediction of internal rate of returns was carried out using the neural network method (NN). Third, the decision-making process was conducted using the analytical network process (ANP).

6.1 Probability Assessment

An integrated probabilistic risk analysis of a mega-road project was done using FTA. The top risk event was selected from the identified risks, which was listed and the user had to choose from it. It was assessed to establish quantitatively the likelihood of the risk occurring during the project's life-cycle. The resultant identified risks were then listed in the risk entry screen for analysis. At this step, each risk was chosen with the different causes events that may lead to its occurrence and increase the degree of its significance (i.e. "Highly likely", "Likely", "Moderately likely", "Slightly likely", and "Less likely") together with its interrelationship with other risk events, as presented in Fig. 3. Figure 3 shows the calculated probability of the risk event that was identified and the rating of probable encountered risk events in infrastructure projects. It also highlights the root causes of each risk.

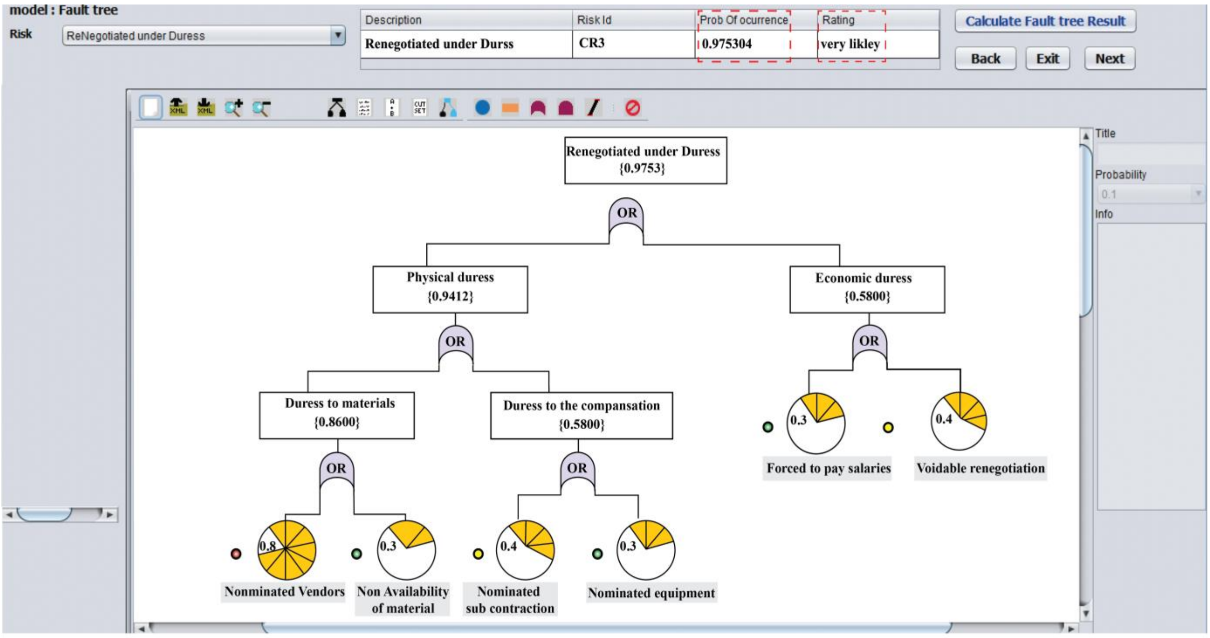


Fig. 3. Probability of Risk Occurrence by RAA3P System.

6.2 Financial Outlooks

The analysis of the business model was carried out using the presented system "RAA3P" from the perspective of cash flow by calculating the indices of financial return on the investment project based on the discounted cash flows. The themes of financial indicators were estimated using an "XLS" spread sheet, which showed the calculation of all variables in investment model as depicted in Fig 4. In the figure, PPP financing has been organized in a specialized scheme that relies on the cash flow of a project as main source of debt repayment. The establishment of a special project company (SPC) and assessment of the future cash flows were considered as the most noticeable characteristics of PPP project financing.

The primary objective of the financial analysis was to use the project's cash flow outlooks to estimate the project's IRR, particularly from the perspective of the private sector. The objective of discounting was to put all present and future expenses and revenues in a typical metric as net present value (NPV), payback period, profitability, and return on investment, as listed in Table 4. The project’s cash flows were obtained by gathering the data of expected revenues, project’s expenses and overhead costs, followed by estimating the financial indicators throughout the RAA3P system, where the operating working capital was used to estimate the private partner cash flows throughout the project's life cycle, as seen in Fig 5.

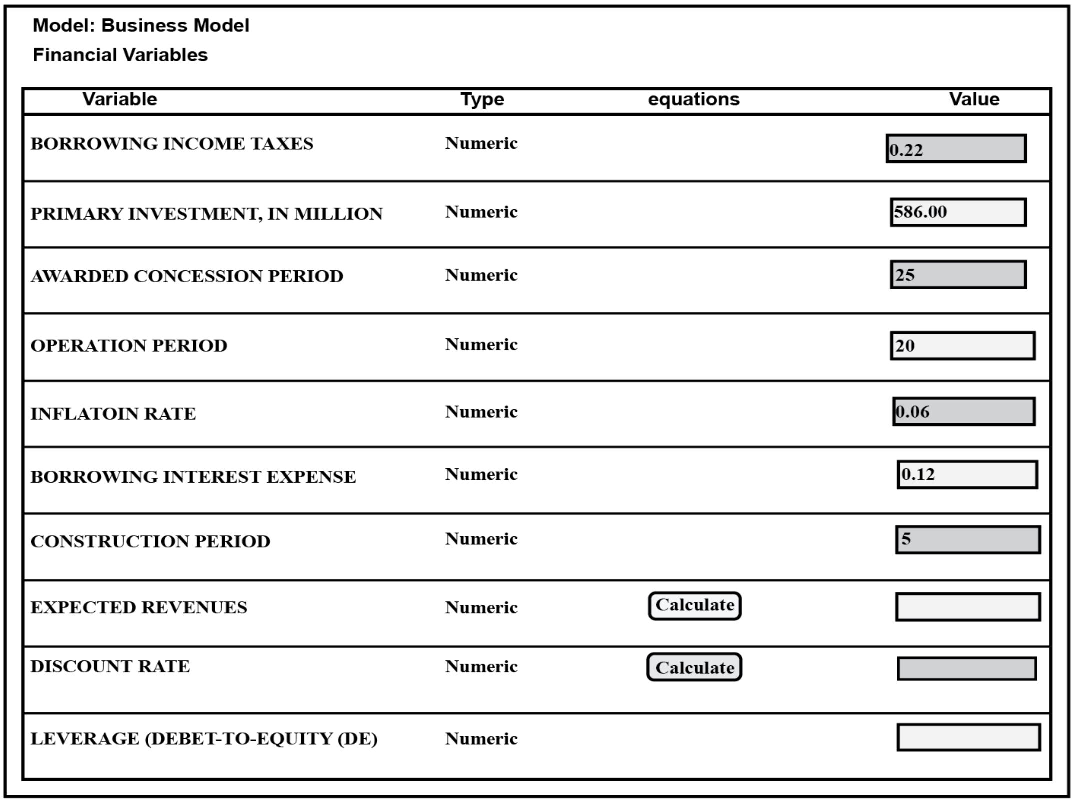


Fig. 4. Business Data Entry Sheet by RAA3P System.

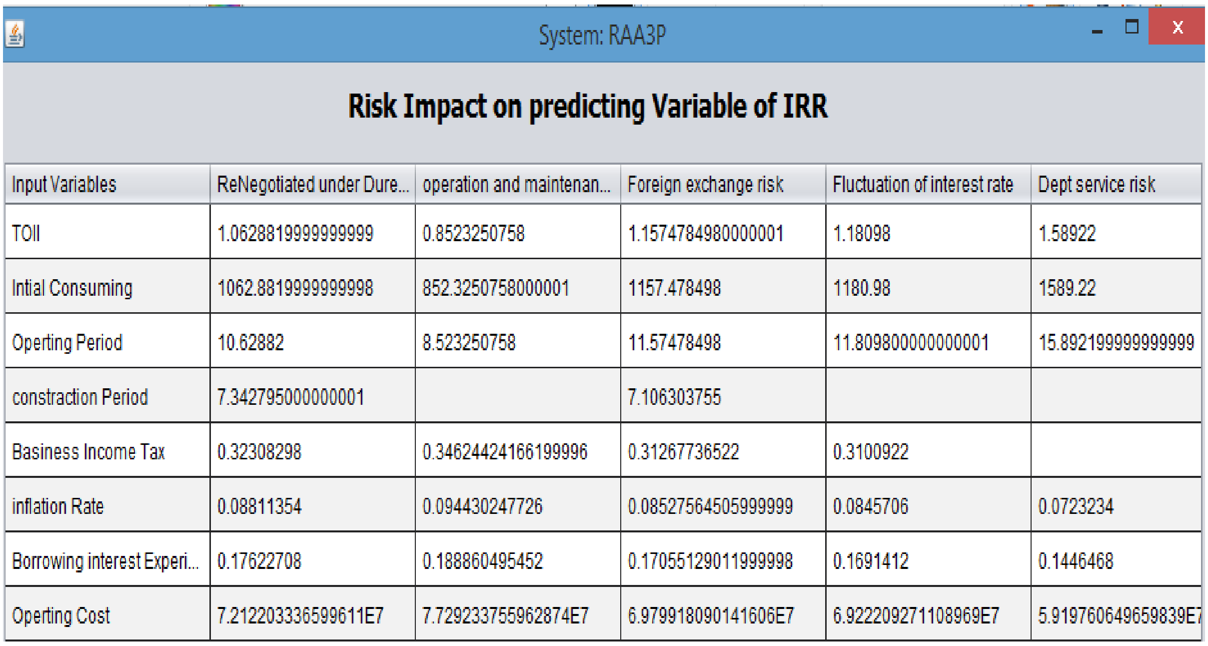
Name	0	1	2	3	4
Net cash flow					
initial investment	586.000				
operating and maintaince					
operating Cost		8030000....	8833000.0	9716300.0	1.068793...
maintance Cost		2190000.0	2409000.0	2649900.0	2914890.0
Total Cost	0.0	1.022E7	1.1242E7	1.23662E7	1.360282...
Revenue and operating Benfit					
Revenue		1.46E7	1.606E7	1.7666E7	1.94326E7
cash flow before Tax	0.0	4380000.0	4818000.0	5299800.0	5829780.0
icome tax calculate					
Depraciation			539.12	495.9904	456.3111...
Total cost	0.0	1.022E7	1.1242E7	1.23662E7	1.360282...
Revenue		1.4E7	1.606E7	1.7666E7	1.94326E7
DCR		41.666667	41.666667	41.666667	41.666667
Net Income Tax	0.0	963600.0	1059841....	1165846....	1282451....
cash flow after tax	0.0	5343600.0	5877841....	6465646....	7112231....
Discount cash flow after tax	0.0	8003.394...	13.18555....	0.021723....	3.579044....
Business Result					
Net cash flow	0.0	534600.0	5877841...	6465646....	7112231....
NPV	0.0	8003.394...	13.18555	0.021723....	3.579044....
Profitability Index	0.0	13.65767...	0.022500....	3.707108....	6.107584....
cash flow after Tax	0.0	5343600.0	5877841....	6465646....	7112231....
Comutative Payback		5343600.0	1.122144....	1.768708....	2.479931....

Fig. 5. Project’s Cash Flow Statement by RAA3P System.

The next module was designed to illustrate the potential effects of different risk factors on the analysis outcome of IRR sensitivity so as to change such factors as toll revenue, operation cost, initial investment and operating period. This module is capable of providing some data in graphical format to inform project managers to help them facilitate negotiations and decision making. Results of the calculation of IRR sensitivity to change the values of such financial factors are shown in Table 4. It was found that almost a 15% change in toll revenues or capital costs changes the target rate of return. It can be concluded that the IRR is most sensitive to changes in toll revenue, followed by operation cost and project investment. Sensitivity analysis was carried out by RAA3P system based on identified risks that included project financing by predicting variables of “IRR” in the context of risk value. It yielded the results for the estimated risk impact on predicting the value of a project's IRR, as shown in Fig 6.

Table 4. Internal rate of Return (IRR) Sensitivity Analysis.

Deviation From Base Case	Financial Sensitivity of IRR		
	Toll Revenue	Project Investment	Operation Cost
-30%	-0.85%	3.01%	2.90%
-15%	0.58%	2.30%	2.30%
0%	1.70%	1.70%	1.70%
15%	2.99%	1.40%	1.60%
30%	4%	0.92%	0.48%



Input Variables	ReNegotiated under Dure...	operation and maintenan...	Foreign exchange risk	Fluctuation of interest rate	Dept service risk
TOll	1.0628819999999999	0.8523250758	1.1574784980000001	1.18098	1.58922
Intial Consuming	1062.8819999999998	852.3250758000001	1157.478498	1180.98	1589.22
Operting Period	10.62882	8.523250758	11.57478498	11.809800000000001	15.892199999999999
constraction Period	7.342795000000001		7.106303755		
Basiness Income Tax	0.32308298	0.34624424166199996	0.31267736522	0.3100922	
inflation Rate	0.08811354	0.094430247726	0.08527564505999999	0.0845706	0.0723234
Borrowing interest Experi...	0.17622708	0.188860495452	0.17055129011999998	0.1691412	0.1446468
Operting Cost	7.212203336599611E7	7.729233755962874E7	6.979918090141606E7	6.922209271108969E7	5.919760649659839E7

Fig. 6. Risk Impact Assessment on Project's IRR.

Figure 7 presents the schematic diagram for project IRR sensitivity. It shows that the expected revenue is the most influential factor in IRR. Also, it depicts that the sensitivity of the results to operation and maintenance costs and capital costs (project investment) almost has the same alignment.

The neural network learns through feed forward architecture from training data, adjusting network structure and connection weights. The system then compares the output it gets with the expected output. The RAA3P system can thus produce forecasts based on the knowledge it has acquired. Finally, the network was presented with project characteristics and was asked to forecast the IRR of the subjected projects using the output of the neural network. A test sample of the predicted values is given in Fig 8.

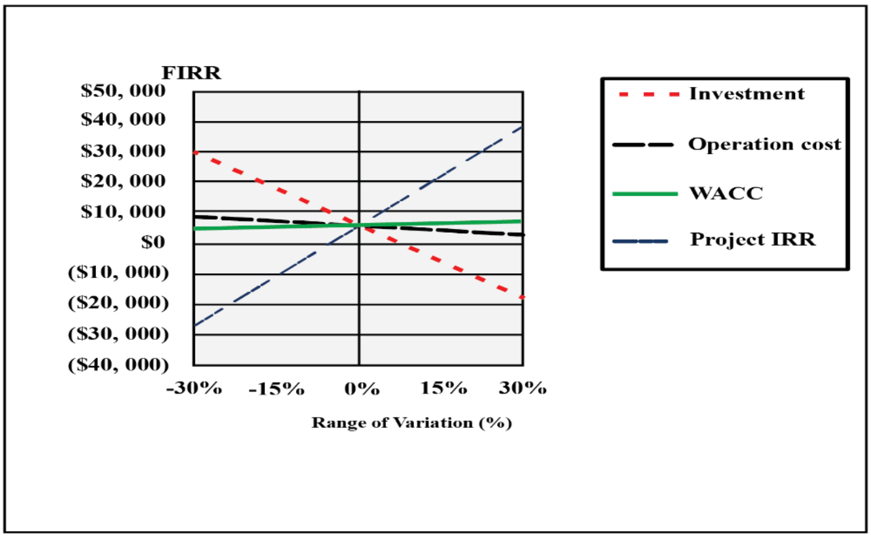


Fig. 7. Schematic Diagram for Project IRR Sensitivity.

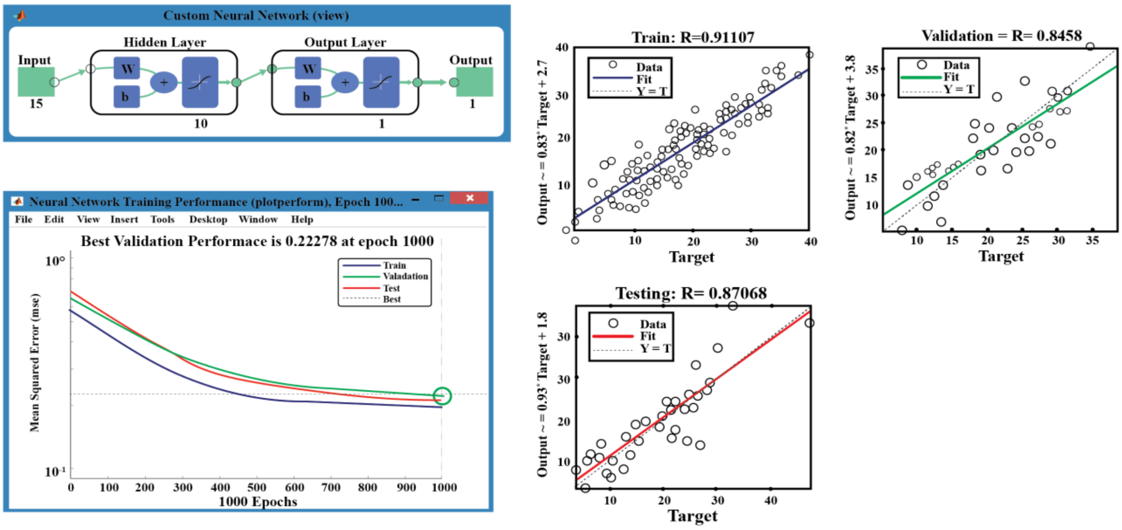


Fig. 8. Predictive Value of IRR by RAA3P System.

6.3 The Analytic Network Process (ANP) for Decision Making

The ANP model was created from the presented RAA3P system through the representation of cause-effect interrelationship dependency between the identified risks and the project's key performance metrics; this was created in a network of relationships. Figure 9 shows the ANP model which was developed for determining the preference of alternative options which were affected as a result of significant risks, and which will support the decision on whether to proceed or not. Furthermore, it depicts how it proposes to adopt the organizational structure of a project to comply with the target IRR.

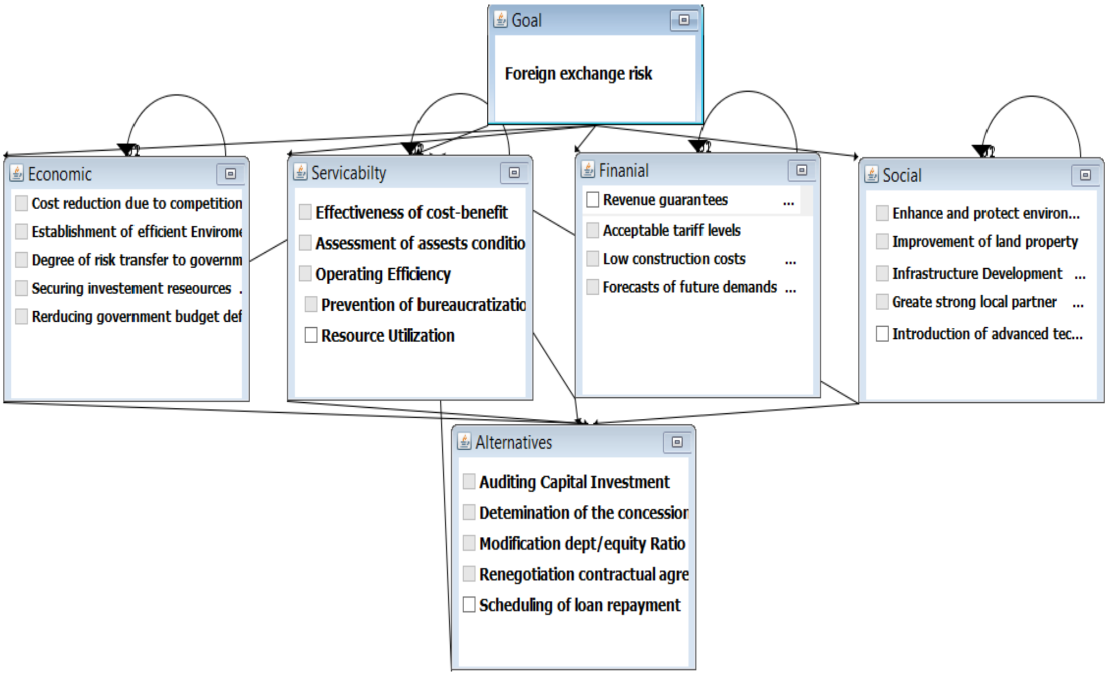


Fig. 9. ANP Model for Key Performance Indicators Evaluation of PPPs.

6.4 RAA3P System Evaluation

The analysis illustrates the achieved IRR for a real case where accurate data is compared to the results that have been yielded by the developed RAA3P system. Figure 10 shows the proposed adoption scheme of the project with regard to the contracting parties as the implementation of RAA3P system. Here, the typical organizational structure creates the need to diffuse risks that are modelled over the whole life of PPP projects by parties through a network of private sector companies involved in the PPP contract, and through the re-financing of investments. The RAA3P system presented in this paper illustrates the efficiency of PPP structure as well as the operational and investment efficiency that compiles the risk assignment according to its probability of occurrence and by prioritizing the given alternatives. It also suggests mitigation procedures. The adoption of the project's scheme from a private sector perspective was intended to minimize the impact of risks on key performance indicators during the project's life-cycle, as usage of side contracts transfers the operation risks that the project's company was subjected to. The proposed adoption scheme warns each contract's party to adjust and negotiate the alternatives that are shown in the adoption scheme according to the priority of alternatives for decision making in order to get optimal returns on investment.

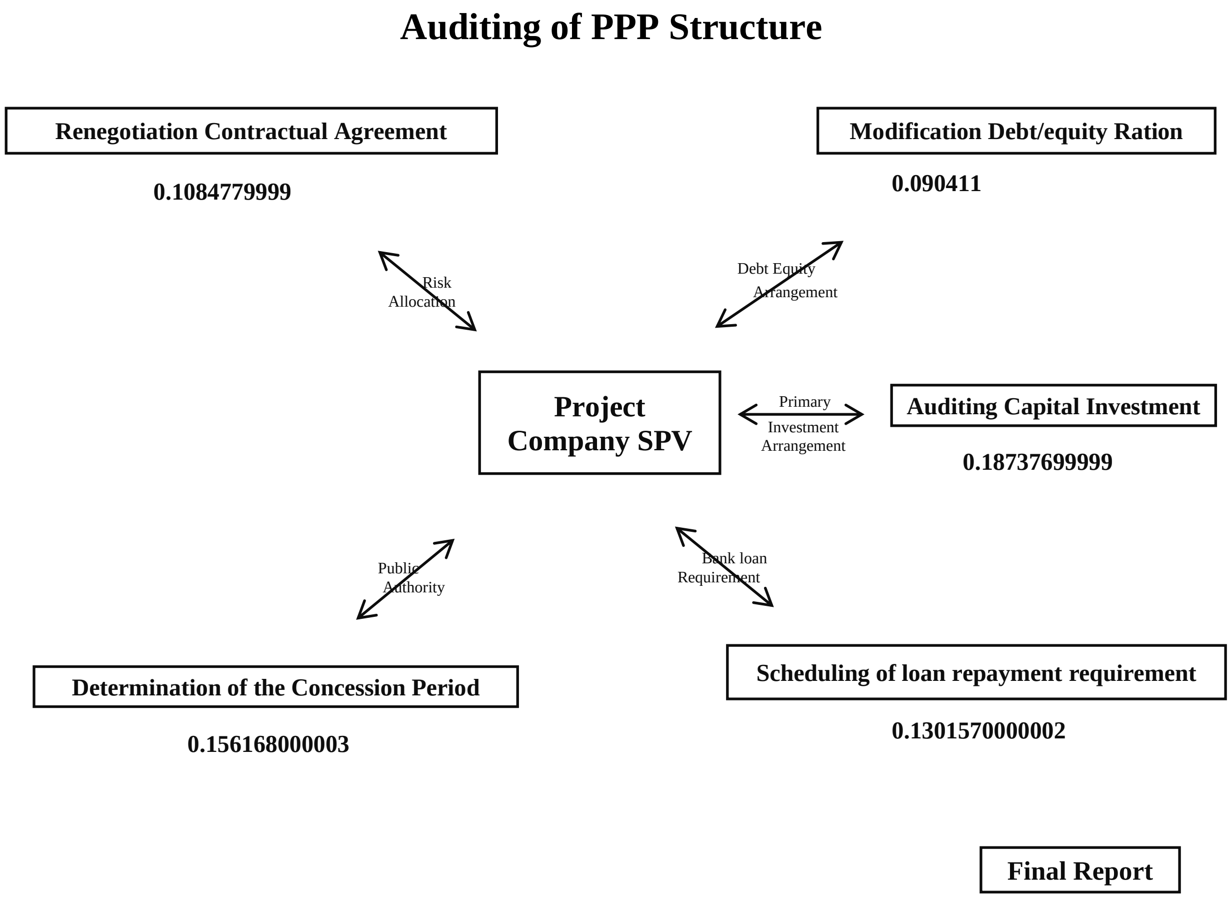


Fig. 10. Proposed Auditing of PPP Structure as per RAA3P Recommendations.

7. CONCLUSION

The proposed framework of this paper provides an improvement over other risk assessment models since it provides a structured way to enhance the risk assessment process in the context of KPIs for PPP projects. It introduces the new infrastructure financing schemes through analysis of the most critical risks. These financing schemes can be utilized to achieve the private investment for large infrastructure projects in Libya to prepare a comprehensive feasibility study, particularly when specialists keep thinking of another financing procedure: precise project risk management. It identifies and estimates the probability of risk occurrence related to the private party, and the alternatives of decisions that support the financial scheme of such class of projects. The proposed framework is capable of evaluating the effectiveness of mitigating measures so that the financial scheme is reviewed to improve the investment. It incorporates a different analytical technique that combines probability of risk occurrence, project-specific financial factors, and ranking the alternatives of decision. It consists an integration method for application of artificial intelligence in construction management, based on probabilistic, prediction, and deductive reasoning in dealing with uncertainty environment that characterize infrastructure PPP projects.

The major contribution of this paper is the development of the RAA3P system. This is a comprehensive framework to assess potential risks that are associated with PPP projects, evaluate them, and suggest applicable mitigation procedures that guide and facilitate the PPP procurement process. It can deal with both quantitative and qualitative risk variables in different efficient analytical tools, such as calculation of the probability of occurrence of potential PPP risks, appraisal and auditing of financing structure, and decision support model to assess risks systematically. In addition, it overcomes the gap between assessment of risks and financial evaluation techniques.

The proposed framework of this research satisfies the aim to improve over other risk assessment models since it provides a structured way to enhance the risk assessment process in the context of key performance indicators (KPIs) for PPP projects as well as enhancement of the proposed financing schemes of projects through analysis of the most critical risks and financing structure of a project. Moreover, this methodology helps in identifying and measuring the various performance-criteria-based risks that affect the alternatives of the decision, which can be utilized for auditing the PPP scheme to achieve the target investment for large infrastructure projects in Libya.

Based on the findings of the present research, future research concerning PPPs could include an analysis of the following topics on the subject of PPP methods for infrastructure projects. Implementing further data is required to ensure better learning from data to modify current knowledge. In addition to acquiring a data base, it is essential for revising the contract clauses that will be modified and refined by the modified system. This will help in doing the financial and risk evaluation of the alternative approaches to investigate the optimal risk assignment for infrastructure PPP projects by considering different types of PPP and different phases of infrastructure projects.

Implementing further data is required to ensure the future research is done in the right direction. The RAA3P system has better learning ability from data to modify its knowledge. The system developed in this paper is a stochastic dynamic framework to enable the integration of different conditions and other risks that arise during the operation phase, and to follow up the effectiveness of payment mechanism to attain the best returns on the project's objectives.

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تطوير نظام متكامل لإدارة مخاطر مشاريع الشراكة

بين القطاعين العام والخاص فى ليبيا

يهدف البحث إلى تطوير نظام حاسوبى لإدارة مخاطر مشاريع الشراكة بين القطاعين العام والخاص فى ليبيا باستخدام المنهج الوصفى التحليلى للبيانات المتحصل عليها من الدراسة الميدانية المدعمة باستبيان احصائى بهدف وضع اطار متكامل لأجراء تحليل للمخاطر وتأثيرها على العائد المستهدف من المشروع وايجاد مرجعية لدعم اتخاذ القرار بناء على البدائل الممكنة للتعامل مع المخاطر المتوقع حدوثها والتدفقات النقدية المستقبلية التى يتم استنباطها أثناء دورة حياة مشروعات البنية التحتية وصولا الى تطوير هيكل ومنهجيات مشروع الشراكة المذكورة فى ضوء مستوى مخاطر المشروع والعائد المتوقع وقد ظهر أن متطلبات الشراكة الناجحة فى ظل نقص الموارد المالية والبشرية لدى القطاع العام، وعدم قدرته على مواكبة التطوّر التكنولوجى تتوقف على عدة عوامل أهمها التحليل الدقيق لجدوى المشروع الاقتصادية قبل التعاقد وتحليل المخاطر من جميع الجوانب الفنّية والمالية والتقنية فضلًا عن المخاطر السياسية تطوير شكل الشراكات التعاقدية من حيث اعادة توزيع المخاطر بين القطاع الخاص والعام وبدائل التمويل.