Al-Azhar Engineering 16th International Conference

Vol. 19, No. 72, July 2024, 300 - 311

THE INTEGRATION OF VALUE AND RISK MANAGEMENT IN STORM DRAINAGE NETWORKS: A REVIEW

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Citation:

M.O. Abdelsalam and A.M. kamhawey, “The integration of value and risk management in storm drainage networks: a review”, Journal of Al-Azhar University Engineering Sector, vol. 19, pp. 300 - 311, 2024.

Received: 20 December 2023

Revised: 20 March 2024

Accepted: 05 April 2024

DoI:10.21608/auej.2024.255746.1527

ABSTRACT

Seeking value enhancement and risk mitigation are inseparable concepts in the engineering field. This is where the need for integration between value management and risk management appears. While value study is a process that identifies unnecessary costs and finding potential performance improvements, risk study is a process that identifies any uncertainties to avoid any negative impacts. This paper will discuss integrating value management and risk management in a Public-Private Partnership (PPP) infrastructure project case study forming the known value and risk management combination through exploring the potential benefits of this twin process and highlighting the intersecting zones between each management type. Both studies have many similarities, as, they are systematic, engages multidisciplinary teams in workshops, and use the very same techniques (like, brainstorming, critical thinking.... etc.). Not only similarities between the two management methodologies, but they are interacting theoretically and in practice. This kind of integration is considered to be a complementary procedure enables each type of management to augment the other. This will allow value management to decrease risk and risk management to magnify value recommending this action as one of the best practice management approaches. The adoption of internal value risk management VRM faces challenges due to its novelty in the industry. To address this, the paper underscores the importance of developing a framework to facilitate VRM studies, particularly in major infrastructure projects. Such a framework would help overcome obstacles and skepticism, ultimately leading to more informed decision-making and successful project execution. As the field evolves, integrating value and risk management will prove increasingly essential for effectively managing uncertainties and optimizing project value.

KEYWORDS: Value Engineering, Risk, Storm Drainage Network, Public Private Partnership, Value Risk Management.

تكامل الهندسة القيمية والمخاطر في شبكات تصريف مياه الأمطار

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الملخص

إن السعي إلى تعزيز القيمة وتخفيف المخاطر هما مفهومان لا ينفصلان في المجال الهندسي .ومن هنا تظهر الحاجة إلى التكامل بين إدارة القيمة وإدارة المخاطر .في حين أن دراسة القيمة هي عملية تحدد التكاليف غير الضرورية وإيجاد تحسينات محتملة في الأداء، فإن دراسة المخاطر هي عملية تحدد أي شكوك لتجنب أي آثار سلبية .ستناقش هذه الورقة دمج إدارة القيمة وإدارة المخاطر في دراسة حالة مشروع البنية التحتية للشراكة بين القطاعين العام والخاص (PPP) التي تشكل مزيجًا معروفًا من إدارة القيمة والمخاطر من خلال استكشاف الفوائد المحتملة لهذه العملية المزدوجة وتسليط الضوء على المناطق المتقاطعة بين كل نوع من

أنواع الإدارة .هناك العديد من أوجه التشابه بين الدراستين، حيث أنهما منظمتان، وتشركان فرقًا متعددة التخصصات في ورش العمل، وتستخدمان نفس التقنيات (مثل العصف الذهني والتفكير النقدي .... إلخ) .ولا يقتصر الأمر على أوجه التشابه بين منهجيتي الإدارة، بل إنهما يتفاعلان نظريا وعمليا .ويعتبر هذا النوع من التكامل بمثابة إجراء تكميلي يمكّن كل نوع من الإدارة من تعزيز الآخر .سيسمح ذلك لإدارة القيمة بتقليل المخاطر وإدارة المخاطر لتضخيم القيمة، والتوصية بهذا الإجراء باعتباره أحد أفضل أساليب إدارة الممارسات .يواجه اعتماد إدارة مخاطر القيمة الداخلية VRM تحديات بسبب حداثتها في الصناعة .ولمعالجة هذه المشكلة، تؤكد الورقة على أهمية تطوير إطار لتسهيل دراسات إدارة مخاطر الطاقة، وخاصة في مشاريع البنية التحتية الكبرى . ومن شأن هذا الإطار أن يساعد في التغلب على العقبات والشكوك، مما يؤدي في نهاية المطاف إلى اتخاذ قرارات أكثر استنارة وتنفيذ المشاريع بنجاح .ومع تطور هذا المجال، سيثبت دمج إدارة القيمة والمخاطر أهمية متزايدة لإدارة حالات عدم اليقين بشكل فعال وتحسين قيمة المشروع

الكلمات المفتاحية : الهندسة القيمية، المخاطر، شبكات تصريف مياه الأمطار، الشراكة بين القطاعين العام والخاص، إدارة مخاطر القيمة.

1. INTRODUCTION

Value and risk management are well known project management practices that allow organizations to deliver successful projects by defining their required outcomes and then exercising processes that maximize value and minimize uncertainty. A successful outcome requires that the value to the business is maximized through the delivery of a facility that gives them the advantages they require within the targeted budget, estimated timeframe and preserving a quality that meets the expectations. To provide an outcome attributed with clarity and full understanding it should be comprehensively illustrated in details and well translated to the project team. Furthermore, to decrease the effect any uncertainty or unexpected event an efficient delivery is highly needed.

Water resources is one of the most importante factors in promoting sustainable development, must be considered during the preparation of economic, social, and environmental sustainability strategies [1-3]. Generally, water resource management must have specific charachtristics including to be sustainable, reliable, and productive especially when considering irrigation and drainage networks. The high efficiency of irrigation and drainage networks achieves the optimal distribution of water in irrigation system [4]. The principal source of water in Egypt is the Nile's water becouse it constitutes for about 95% of the total available sources of water where the rest are rainfall and groundwater.

Currently, the estimated total available freshwater resources were around 60 km^3 y^{-1} [5]. The total water consumption in 2021 was roughly 80 km^3 y^{-1}, from which 76.6% is used in the agriculture sector [6] while the residual is utilized in urban and industrial uses. Under the current situation, irrigation water sources in Valley and Delta are 41.28 km^3 y^{-1}. Nile freshwater plus 20 km^3 y^{-1} agricultural wastewater reuse and shallow groundwater used to irrigate a total area of 3.78 million ha (9.1 million feddans, one feddan = 0.42 ha). This involves 2.25 million ha of Old Fields, the Delta and Valley conventional agriculture, and 1,53 million ha of New Fields, including reclaimed land from the desert next to the Old Lands or in the oasis, North Sinai Development Project, Touskh Project [7].

Over the past 30 years, many projects have tried to organize farmers, develop the coordination between farmers and irrigation managers, or develop "water boards" at the district level to ensure that all stakeholders are includ the problems related to irrigation water management in the irrigation networks for Egypt's Nile Delta New Lands. These problems include the damage of the concrete lining, control structure gates, weeds growth, sedimentation problems occured in irrigation networks and the arrival of sewage and sweeping into the canals, disregard for canals limit. Those problems can be classified as building materials quality, design problems, bed soils geotechnical properties, maintenance and operation, execution, and social problems [8].

The shortage of freshwater sources, climate change and the shortage of freshwater quality have a great impact on the lives of human beings. Hence, improving the design of irrigation canals will reduce water losses due to evaporation and seepage. Particle swarm optimization (PSO) is used to study the optimum design of irrigation canals' cross-sections with the objective to reduce the overall costs. The total costs include lining, the costs of earthwork, and water loss by seepage and evaporation. The velocity constraints for erosion and sedimentation have been taken into consider in the proposed design method. The proposed PSO is compared with both the Probabilistic Global Search Lausanne (PGSL) and classical optimization methods to verify its usefulness in optimal design of canals' cross-sections. The proposed PSO is then used to design El-Sheikh Gaber canal, north Sinai Peninsula, Egypt and the obtained dimensions are compared with the existing canal dimensions. To facilitate the use of the proposed model, optimal design graphs are presented. The overall reduction in cost ranged from 28 to 41%, consequently and the proposed PSO algorithm can be reliably used for the design of irrigation open canals without going through the conventional and cumbersome trial and error methods [9].

Irrigation canal network problems are due to insufficient design, execution, and poor operation and maintenance. The main problems of irrigation networks in Egypt and remediation measures for rehabilitation and optimal irrigation for 3.78 million ha has been evaluated. On the other hand, recent studies have shown that most of the existing networks, which have been constructed with colossal costs, suffer from various technical and social problems during the construction and operation processes. This purpose can be achieve through (i) strategic planning methods and guidelines have been used to analyze and assess the irrigation networks; and (ii) field studies, visits, and organization of main and sub-main committees with stakeholder participation have been carried out, and (iii) review of literary works and holding of workshops have been applied. Based on the outcomes during the workshops and the main committee, all problems of irrigation systems were categorized into six main topics developing irrigation network systems; environmental assessment; improvement of design quality; improvement of supervision and execution; improvement of operation and maintenance; and monitoring of the system. For each topic, the existing problems in the networks were presented separately in the form of a problem diagram and then a target diagram was developed to optimize and modify the networks. An attempt was made to consider the different core criteria and set time priorities (short, medium, and long term) to determine the performance of the proposed executive and research strategies [10].

Urban stormwater is runoff associated with rainfall or snow which may carry various pollutants such as debris, nutrients, litter, toxic chemical materials, and sediments near to the residential areas [11]. Moreover, stormwater can carry bird droppings, animal waste, heavy metals, and various cancer-causing substances and anthropogenic pollutants from roofs and roads into downstream water bodies [12]. These contaminants can impair the hydrology, the aquatic environment, and the life of urban dwellers [13]. Moreover, stormwater runoff flows over the urban impervious surfaces and causes flooding, heavy casualties, and traffic paralysis [14].

Stormwater infrastructure systems are designed to control flash floods and to enhance the quality of water in rivers and streams [15]. Currently, urban water infrastructure is facing growing pressure as a result of continuous fluctuations of climatic and socio-economic factors. These factors lead to sewer pipe damage, flash flood problems, and serious degradations in the quality of a citizen's life [16]. In addition, the quantity of water entering the sewerage systems is increasing due to urbanization and the wide application of water-resistant surfaces such as asphalt and concrete pavements [17]. Hence, maintenance, upgrading, expansion, and rehabilitation of the current water infrastructure systems are urgent needed as these projects are characterized by an extended long service life (e.g., over 50 years).

Recently, several regions in Egypt, especially the coastal strip region, have been suffered from severe and unexpected flash floods [18]. Although this stormwater runoff causes many problems, it can be harvested and used for non-potable applications such as toilet flushing, road cleaning, vehicle washing, and other non-irrigational purposes [19]. Several green infrastructural systems, which use tree plantation, grasslands, soils, and other ecological elements, have been designed to harvest and control stormwater runoff [20]. However, the feasibility of this technology in Egyptian cities,towns, and governorates is currently under investigation.

This paper will focus on applying the integration of value and risk management in the storm drainage networks design works as a major part of the infrastructure cost along a single study process. A case study was selected to apply the adopted practice to provide a direct guideline to show how to integrate the two methodologies and where.

2. Value Management

Lawrence Miles or the "father of value engineering", during working with a big company like General Electric in 1940s, he didn't fear to think in a different method to solve the problem of the manufacturing materials shortage. Instead of searching for alternatives to keep supplying the industry, he started analyze the components of the product itself to find out what the function of this component and what else could perform the function, because the customer needs the function, nothing else. This mindset opens the door wide for innovations resulted in marvelous products with reduced cost without affecting the function of the component. Miles named his technique value analysis, to pass through several stages and evolve to keep the term of value analysis in use until today [21].

Value Analysis (VA), Value Engineering (VE), Value Management (VM) all these terminologies are describing any value endeavor, with a slight difference that value analysis is held for an existing product, value engineering is held for a new product and the value management is held for a system, for instance, an administrative system.

Currently, the Society of American Value Engineers (SAVE) presents value management, analysis and engineering as value methodology as they are interchangeably used. (Save International - Value Eng.)

When applying value management at the start of any project, it creates a common language for communication among the engaged parties leading to a full understanding of the customer requirements which eventually increase his satisfaction. Also, the following are considered to be benefits for applying the value management [22].

- As the value is better described by the customer, it gives the best definition for the value in the terms of function and quality.
- Provide justifications and basis for decision making.
- Allow the balance between various stakeholder requirements.
- Improve communication.
- Allow prioritizing the customer demands.
- Act as a quality assurance for the project.
- Ensure cost effectiveness.

- Allow measuring value and obtaining value index.
- Considering non-monetary value.
- Allow innovations in designs. Fig. summarize the benefits of value engineering [23].

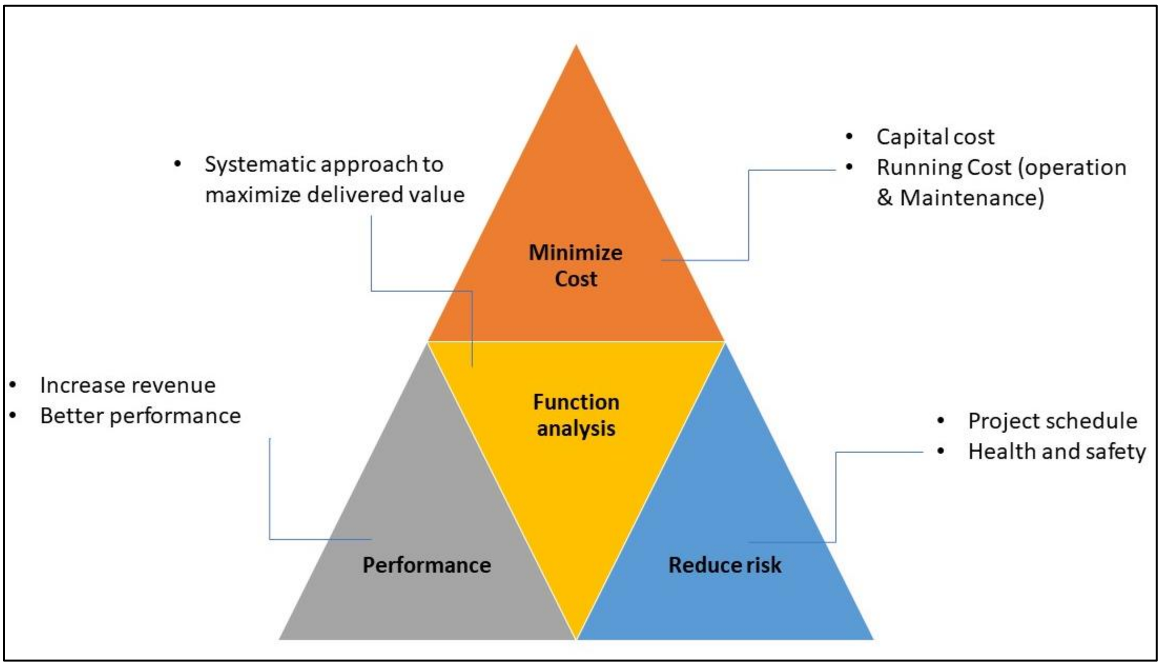

Fig. 1: Benefits of Vlaue engineering [23].

Urban Stormwater Management is an activity involves technical and institutional aspects for controlling quality and quantity of runoff is called stormwater management [21]. indicates estimation of Runoff volume frequency distribution and peak discharge rate as one of the task in urban stormwater management. Stormwater management plays major role in preventing flood [24]. Urban Stormwater management helps to manage the problems arise from imperviousness of urban areas such as decreasing in ground water recharge, high frequency of flooding, instability of stream channels and damage to infrastructures, has been statied. Stormwater management also have economic benefits by reducing the maintenance and cleaning cost of stormwater drainage systems and increasing their lifetime.

Stormwater management is complex in nature but because it is basic for the functioning of urban environment, it gains much attention and evolving overtime [25]. Because of its complexity different methodologies, approaches and techniques are observed in the reviewed studies and as points the use of hydrological models specifically designed for stormwater management purpose called stormwater models become common [26].

In stormwater management following environmentally safe and nature friendly measures is essential. The measures that are designed to restore or resemble the natural infiltration patter have a great role in reduction of runoff volume and regulate peak flows thus can reduce flooding problems in urban areas [27]. The term used in natural friendly stormwater management approaches vary in respect to countries, context and time but with similar design philosophies. Some of the terms are best management practices (BMPs), sustainable drainage system (SuDS), surface water management models (SWMMs), storm control measures (SCMs), low impact development (LID), water sensitive urban design (WSUD) and green infrastructure [27-29].

3. Risk Management

Risk is defined as the uncertainty of an outcome [30], whether it has a good or negative impact, and risk management (RM) is the process that includes the necessary actions to identify, monitor, and manage project risks. Risk is the probability of occurrence of an internal or external event, that may cause a deviation on achieving the project goals or the possibility not complete it at all. Since there are many threats associated with storm drainage endeavours, therefore, effective risk management is crucial to any storm drainage project.

For instance, the nature of the infrastructure industry's activity, from the initial investment evaluation of a project through to the project's actual completion, leaves it sensitive to risk and uncertainty. This field has the high risk and uncertainties and should be taken in consideration.

One of the areas of expertise emphasized by the Project Management Institute is risk management [30]. Moreover, dealing with risk in the field of management is a well defined and structured method of identifying, evaluating, and responding to risks in order to acheive the project goals of the institute of Risk Management (lRM).The identification and analysis of risks, as well as the enhacment of the steps for managing projects and the best utilization of resources, are factors that give the risk management process its superiority.

The orgainized process of recognizing, assessing, and responding to project risk, including increasing the likelihood and implications of good occurrences and decreasing the probability and consequences of negative impacts on the project targets, is how risk management (RM) is illustrated. A risk is "the implications of the existence of significant uncertainty about the level of project performance achievable has been stated," and a risk is "an unsure set of circumstances that, if take place, will have an effect on reaching the project's targets [30, 31]. “There are several methods for managing risks, and most practitioners, according to [32], have created their own methodologies tailored to the projects they work on. The six components of the standard model are detailed in Table 1 and include risk identification, risk analysis, risk response, and risk monitoring and review.

Table1: Risk Management Stages [30].

Plan Risk Management	The procedure used to manage risks during project activity.
Risk identification	The procedure for identifying risks to the project, (risk register)
Analyze risk qualitatively	The procedure of prioritizing risks for further investigation or action by weighing their effect and occurrence possibility.
Analyze risk quantitatively	The procedure of quantitatively evaluating how recognized risks will impact the endeavor.
Plan Risk response	The procedure of coming up with alternatives and measures to improve opportunities and decrease threats
Control Risks	The procedure of Implementing risk management plan, monitoring recognized risks, tracking residual risks, and finding new risks

The impact and probability rates that will affect the risk analysis evaluation by determining the resourses to redusce and monitor the impact of uncertain events to increase the achieving of the opportiunities shown below in the Tabel 2 while **Fig. 2** present the risks severity matrix [30].

Table 2: Impact, Probability Rates and Values [30].

Impact		Probability	
Rates	Value	Rates	Value
V. High	0.80	V. High	0.90
High	0.40	High	0.70
Meduim	0.20	Meduim	0.50
Low	0.10	Low	0.30
V. Low	0.05	V. Low	0.10

Probability	Threats				
0.9	0.045	0.09	0.18	0.36	0.72
0.7	0.035	0.07	0.14	0.28	0.56
0.5	0.025	0.05	0.1	0.2	0.4
0.3	0.015	0.03	0.06	0.12	0.24
0.1	0.005	0.01	0.02	0.04	0.08
Impact	0.8	0.4	0.2	0.1	0.05

Fig. 2: Risks Severity Matrix [30].

4. Value and Risk Management Integrating.

The primary goal of VM and RM integration, or VRM, is to maximize value for a project. According to [31] that describes the structure for a mixed or combination between value and risk as per Table 3 and Figure 3 - 5 shows the process for each, when significant risks occur that prevent project delivery and reduce value, it is unnecessary to devote great effort to optimize a project's value; conversely, a project in which all risk are eliminated has little chance of maximizing value. Taking in consideration that keep using these strategies solely will lead to a larger consumption for two important resources, financial resources and time as a valuable resource [34]. The OGC (2003) [35] recommended performing VM exercises first in order to define precisely what the business would receive as value after the completion of a project.

The advantage of the (RM) and (VM) integration can be achived through the following:

- new methodology for addressing the business requirements, including the agility required to address the upcoming challenges.
- improved comprehension of the description of certain stakeholder demands.
- All suggestions, substitutes, and innovative ideas are oriented.
- More value index for investment and meeting end-user criteria should be presented.
- lowering unnecessary costs by removing of waste and inefficiencies.

In light of this, it makes sense and is doable to combine the two procedures in single research. A responsible person should regularly examine and report on the implementation and management action progress in the regular project reports. The actions arising from the combined value and risk research are likely to be carried out and reported independently at this time, in between official investigations. This is due to the possibility that several members of the project team may be in charge of carrying them out.

Table 3: The format for a typical combined study [36].

Value	Value and risk	Risk
Stage-I Preparation	Stage I – preparation	Stage-I – prepare Stage-II identify
Stage-II function analysis workshop	Stage II – workshop briefing, function analysis. Stage III – review risk register	Stage III – analyze Stage IV – evaluate (quality)
Stage-III creativity	Stage IV – generate improved ideas	Stage V – plan
Stage-IV evaluation	Stage V – Idea selection	
Stage-V development	Stage VI – develop proposals and quantify risk allowance	Stage VI – evaluate (quantity)
Stage-VI presentation and reporting	Stage VII – report compiling and presentation	Stage VII – present reports
Stage-VII implementation and reviews	Stage VIII – implement Proposed actions, Carry on usual reviews	Stage VII – implement and review

Fig. 3: Value engineering Process [36].

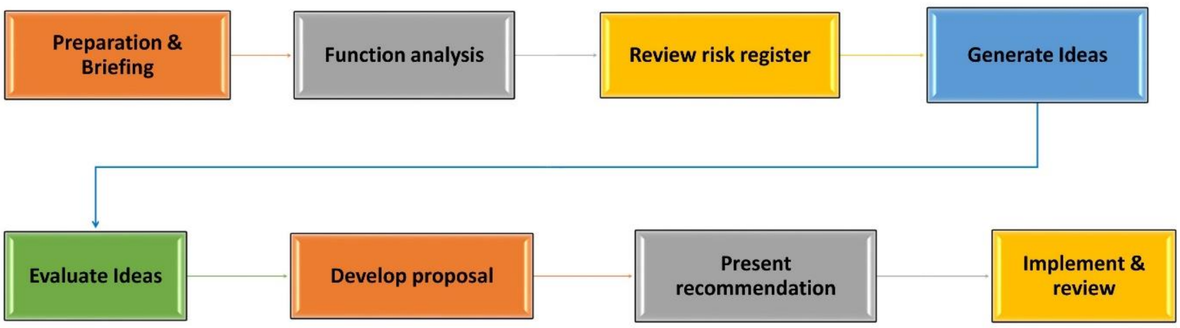

Fig. 4: Value and Risk Process [36].

Fig. 5: Risk Process [36].

5. Case Study

The project is basic infrastructure design works (grading, road network and storm drainage system design work only due to tight budget) for a mixed-use complex with 1.5 million m^2 and about 6 km running pipes, located in KSA surrounded with an existing road network.

The value risk management (VRM) study takes place especially for the storm drainage network as a pilot. The project objectives were as the following:

- Protect the site from any hazards of internal flood against any rainfall events according the relevant authority regulations.
- Ensure draining the storm water and conveying the collected discharge to a safe disposal point.
- Integrating the drainage system with the existing flood mitigation system in the vicinity.
- Provide a safe and economic design.
- A life time span for the network to be 100 years.
- Create a flood risk map for the site to be able to assess the water depth breach for the properties.
- Constructing a storm drainage network that needs minimal maintenance.
- To use local materials for the storm drainage network components to facilitate the construction, minimize the consumed time and ensure cost effectiveness.
- Achieving the maximum percent of saving, as the main driving force.

An internal value risk management (VRM) workshop included multidisciplinary team, who initiated it by project scope of work identification, taken into account the saving constraint. Afterward, the team identified the risk associated with each design alternative. This is to be able to choose the most convenient alternative could be adopted. A brain storming technique was followed by the team members and the facilitator

The well- established value methodology six phase job plan was dominant during the workshop, due to the presence of certified value methodology associates among the team, which also contributed in the knowledge transfer to the other team members.

More alternatives were introduced on the creativity phase, then the usual evaluation mentioning the advantages and disadvantages of each alternative. In addition, technical, business and management risk assessment occurred for the chosen alternative. For instance, the following risks were registered:

- Lack of information during design stage (for example, unavailability as-built drawing for surrounding networks)
- Permits approvals from the relevant authorities (for example, approval on tie in point)
- Construction issues (for example, pipe connection leakage)
- Climate change (for example, unexceptional rainfall events)
- Incorrect information (for example, field survey errors)
- Saudi 2030 vision requirements (for example, tight time frame)
- Financial problem (for example, inflation cost)

Least but not last, the developing for the chosen alternative applying the standards and local regulations within the given time frame. Eventually, all the outcomes of the study were presented.

Conclusions

The main reason and motivation for this paper was the scarcity of applying an integrated value and risk management (VRM) studies and the resistance that this protocol face when introduced to clients. The case study presented in this paper, mentioned as an example for a successful application for the value and risk management that showed the similarity aspects between the two combined managements types, starting from the aims passing through the used techniques till the positive impact results. For instance, some unified objectives that have been identified as the following:

- several stakeholders.
- assumptions.
- constraints.
- key functional elements of the project.
- advantages and disadvantages of the chosen alternative.
- more accurate cost estimation.
- value engineering opportunities .
- time scale for each task to be accomplished.
- finalized action plan.

Based on the research done in this paper, a lot of obstacles and opponents hinder undertaking the value and risk management studies as it is relatively new, However, developing a frame work that facilitate undertaking such studies is a must, especially in the major infrastructure development projects.

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