Risk Analysis Facing potable and Waste Water Projects in Egypt (Owner View)

Elsanabary, Mohamed H. Nema, Amira S, Tolba, Ehab R.3 and Hassan, Hassan M.

Abstract— Egyptian Government has increased its intention to support potable and waste water projects. One of the challenges facing these projects in Egypt is how to assess risks that affecting this kind of projects. Risks cause an increase in cost, time delays and lack of project quality. The purpose of this paper is to identify risk factors that affect waste water projects in Egypt and assess the impacts of such factors in waste water project's cost and time. The research study area was taken in Damietta, Egypt through five years' time frame from 2011 to 2015. Eight major risk factors were identified to study their impact on the cost and time of waste water projects. The study claims that cost and time related risks are most likely to occur and have the major influence on replacement and renovation of waste water projects. at the bottom of this column. Don't use all caps for research paper title.

Index Terms— risk analysis, potable water, waste water, principal component analysis, risk in water project, risk facing owner, potable and waste water in Egypt

1 Introduction

Potable and Waste water service measures the social and healthy progress of urban/rural communities. On a global level, problems of these type of projects are the largest source of pollution. Such problems could include: population growth, lack of waste water capacity estimate and inaccurate planning especially in the developing countries. According to the United Nations' Human Development Report, there is a remarkably absence of effective national policies especially in waste water services more than potable water. Also, there is a strong relationship between poor access to drinking water and waste water service and health aspects.

Egypt is one of the early countries that constructed waste water projects in the Middle East. In 1914, sewage main department has been established. The sewage sector was managed by many authorities, but the lack of coordination between authorities caused lots of problems to appear. In 2004, the holding company for potable and waste water was established as an independent entity affiliated to the Ministry of Housing. The holding company is responsible for potable water and waste water sectors. Currently, this vital sector is facing many challenges. The most important challenges are increasing in population and industrial and agricultural activities. Potable and Waste water projects can be extremely complex and full with uncertainty. Potable and Waste water projects can be categorized into two main categories; First, new construction projects which include: Establishing new networks and Create new treatment or purifications plants.

In year 2006/2007, the total number of replacement and renovation projects, which listed according to the Egyptian government five year plan, is 222 projects as the year target all over the country. Only 4 projects were completed with 3.8% of the target and 25 projects have been completed, partially, through 2006/2007 then delivered in 2007/2008. It was found that other projects about 193 projects are delayed in the implementation more than one year and some of them delayed to 2011/2012. Risks in waste water projects affect cost and project time. Consequently, that leads to delay benefit of the projects and therefor the unsafe disposal of wastes, increasing pollution and disease. The large construction companies that granted the implementation of potable and waste water projects might hire some subcontractors. In many cases the subcontractors are eligible to work in those major projects which need physical potential and human experience. Accordingly, that would lead to wasting a lot of money and time without any use. The most critical risk is the lack of clear vision of the project from the beginning which causes modification of project drawings and maps, in addition to other modifications that appear during the work in the field of the project.

Risks come from many sources as incorrect design, project team, site problems, etc. Moreover, the size and complexity of waste water projects increases the risks. Risk and uncertainty cause potential damage consequences to the construction of waste water projects. Cohen et al. (2004) defined risk as the potential for complications and problems with respect to the completion of a project and the achievement of project goals. The Uncertain future event or condition, with occurrence rate greater than 0% but less than 100%, has an effect on, at least, one of the project objectives, schedule, cost and quality. Furthermore, the impact or consequences of this future event must be unexpected or unplanned. It is well accepted that risk can be, effectively, managed to mitigate its adverse impacts on project objectives even if it is inevitable in all project stages. It

- *Author name is Assistant professor, Civil Engineering Department, Port Said University, Egypt. Elsanaba@ualberta.ca*
- *Co-Author name is currently pursuing master's degree program in civil engineering in port said University, Egypt. Th_rouse@yahoo.com*
(This information is optional; change it according to your need.)

is important to face these uncertain risks by assessing their impacts on the project objectives.

Managing risks involves identifying, analyzing and prioritizing risks. This will occur by monitoring, controlling, and applying managerial resources with coordinated and economical effort. Managing risks minimizes the probability and/or impact of unfortunate events and maximizes the realization of project objectives (Hubbard, 2009). Effective risk management may lead the project manager to several benefits such as identification of favorable alternative course of actions, increased confidence in achieving project objectives, improved chances of success, reduced surprises, more precise estimates (through reduced uncertainty) and reduced duplication of effort (through team awareness of risk control actions). Risk analysis and management continue to be a major feature of the project management. Risk analysis is dealing effectively with uncertainty and unexpected events to achieve project success. The main objectives of this research are:

I. Defining potable and waste water projects in Egypt
II. Explaining potable and waste water projects types
III. Identifying risks that facing this type of projects
IV. Analysing the risk impacts as time increase and cost overrun in waste water projects.

2. DATA DESCRIPTION

There are different types of risks associated with the construction activities. These risks might be physical, environmental, design, logistics, financial, legal, political, construction and management risks. The study area was taken in Damietta, Egypt through five years' time frame from 2011 to 2015. By studying and reviewing all the archived documents of the 222 projects, Table 1 shows that there are 33 types of risk factors affecting potable and waste water projects through 2011 to 2015 which causing delay in project time and cost overrun. Risk can be repeated in the same project more than one time during the various stages of implementation. Most of these risks are depending on each other and affecting on each other. For example, incorrect design risk could lead to inaccurate quantities in the project and mean more project cost and time due to both risks incorrect design and inaccurate quantities.

Potable and Waste water projects are one of the infrastructure projects. The life cycle of potable and waste water projects from the origin started by construction then followed by operation and maintenance, replacement and renovation, operation and maintenance then finally demolition. Table 2 shows that replacement and renovation of waste water projects has the largest annually share more than new construction. New construction is more complex and need more detailed studies. Also, new construction should provide land spaces to establish treatment plants and networks. In 2013, waste water projects were 100 projects with new construction projects present 2% of waste water projects while replacement and renovation present 98% of waste water projects.

Studying risk effect in potable and waste water projects requires assessment of risk facing these types of projects. From the archived documents of Damietta holding company for potable and waste water from 2011 to 2015, the average number of implemented projects was about 155 projects annually. The average number of projects exposed to risk during the same period was about 105 projects annually. Through the 5-years study period, waste water project had 440 projects with replacement and renovation of waste water projects represented 429 projects and new construction projects represented 11 projects. About 68% of projects were exposed to risk. Waste water project have the most shares in the holding company projects. The number of risky projects was 275 projects i.e. 55 projects exposed to risk annually and most of them were replacement and renovation projects.

Risk facing waste water projects can be divided into two main categories:

- Technical risks: affecting the project site and depends on design and drawings, they can present in defective design, gaps between implementation and specification, design change and not coordinated design

Managerial risks: depend on the factors that affect the projects from the company side, such as company policies, communication between individuals and the relation between the company and other authorities. Managerial risk is representing in Poor communication between involved parties, Changes in management style, Lack of data and difficulty to get permits.

3. METHODOLOGY

Because if the dependency of risk factors which represented in Table 1, to overcome this issue a statistical technique called the principal component analysis (PCA) is used to classify the risk factors into categories. PCA is a statistical technique which used to analyze the inter-relationships among a large number of variables and explain these variables in terms of a smaller number of variables (Elsanabary and Gan, 2014). Principal component analysis (PCA) is a multivariate technique that analyzes a data table in which observations are described by several inter-correlated quantitative dependent variable (Abdi, 2010). PCA is useful for finding clusters of related variables and thus ideal for reducing a large number of variables into a more easily understood framework (Badu, 2009).The goals of PCA are, (Abdi, 2010):

- Extract the most important information from the data
- Compress the size of the data set by keeping only this important information.
- Simplify the description of the data set.
- Analyze the structure of the observations and the variables.

Table1

Classifications of risk factors that affect **THE POTABLE AND WASTE WATER PROJECTS WITH THE CODE OF EACH FACTOR**

Risk Class	Risk Factor	Code
Design risk	Defective design (incorrect)	R1
	Rush design	R2
	Awarding the design to unqualified designers	R3
	Not coordinated design (structural, mechanical and electrical)	R4
	Lack of consistency between bill of quantities, drawings and specifications	R5
	Inaccurate quantities	R6
Environmental risk	Difficulty to access the site	R7
	Adverse weather conditions	R8
	Acts of God	R9
Physical risk	Supplying invalid materials	R10
	Change the productive capacity of labor and machinery	R11
	Unavailable labor, materials and equipment	R12
	Occurrence of accidents because of poor safety procedures	R13
Logistics risk	Inaccurate project program	R14
	Poor communications between the home and field offices	R15
	High competition in bids	R16
	Undefined scope of working	R17
Financial risk	Delayed payments on contract	R18
	Financial failure of the contractor	R19
	Exchange rate fluctuation affecting material and equipment price	R20
	Monopolizing of materials due to closure and other unexpected political conditions	R21
Legal risk	Difficulty to get permits	R22
	Legal disputes during the construction phase among the parties of the contract	R23
	Delayed disputes resolutions	R24
	Ambiguity of work legislations	R25
Construction risk	Gaps between the Implementation and the specifications due to misunderstanding of drawings and specifications	R26
	Undocumented change orders	R27
	Design changes	R28
	Actual quantities different from the contract quantities	R29
Management risk	Poor communication between involved parties	R30
	Changes in management ways	R31
	Information unavailability	R32
	Resource management	R33

Table 2

Total annually **NUMBER OF PROJECTS AND NUMBER OF POTABLE WATER PROJECTS (NEW CONSTRUCTION AND RENOVATION) IN DAMIETTA HOLDING COMPANY FROM 2010 TO 2015**

Year	Total number	Potable water projects	New construction projects	Replacement and renovation
2010/2011	150	70	1	69
2011/2012	110	50	2	48
2012/2013	180	80	2	78
2013/2014	210	80	3	77
2014/2015	120	50	1	69

Table 3

Total annually number of projects and number of waste water projects (new **CONSTRUCTION AND RENOVATION) IN DAMIETTA HOLDING COMPANY FROM 2010 TO 2015**

Year	Total number	Waste water projects	New construction projects	Replacement and renovation
2010/2011	150	80	1	79
2011/2012	110	60	2	58
2012/2013	180	100	2	98
2013/2014	210	130	3	127
2014/2015	120	70	3	67

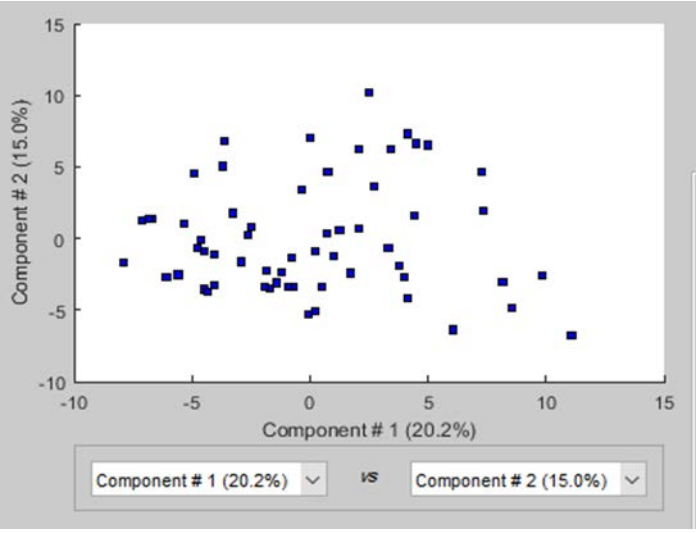

Figure1: scatter plot for component 1 and component 2 resulted from PCA

There are 8 major risks resulted from PCA as shown in Table 1. These risks are sorted in a descending order with respect to their effectiveness:

- Defective design (incorrect),
- Not coordinated design (structural, mechanical and electrical),
- Difficulty to get permits as roads or traffic permits,
- Gaps between the Implementation and the specifications due to misunderstanding of drawings and specifications,
- Design changes,
- Poor communication between involved parties,
- Changes in management ways,
- Information unavailability.

4. RESULT DISCUSSION

From the PCA results, the 8 major risk factors that affect in potable and waste water projects with high percentage from 2010 to 2015 are shown in Table 1. Studying effect of the 8 major risk factors in waste water projects. Table 3 shows that "defective design" risk factor was affecting , in average, 49% of the total waste water projects annually, started with 68% in 2010 and ended with 36% in 2015. The "Not coordinated design" risk factor affected was affecting, in average, 22% of the total waste water projects annually, started with 23% in 2010 and ended with 9% in 2015. The affected ratio decreased from 2011 to 2015, but the total number of risky projects sill high and hampered the utilization of the project.

The total number of waste water projects in 2010 is close to that of 2015. In 2011, the total number of waste water projects was 80 projects with 55 projects affected by the risks. In 2015, the total number of waste water projects was 70 projects with 40 projects affected by the risks. The percentage decreased but the risk still affecting the projects with high percentage.

Table 3
Approximate occurrence percentage
of each of the 8 risk factor in waste water projects (2010 - 2015)

Year	Total no. of projects	Risky project	Defective design	Not coordinated design	Difficulty to get permits	Gaps between Implementation and specifications	Design changes	Poor communication between involved parties	Changes in management ways	Information unavailability
2010/2011	80	69 %	68 %	23 %	23 %	44 %	23 %	24 %	18 %	19 %
2011/2012	60	83 %	55 %	30 %	23 %	33 %	25 %	12 %	11 %	12 %
2012/2013	100	60 %	50 %	30 %	11 %	35 %	27 %	27 %	36 %	10 %
2013/2014	130	54 %	38 %	19 %	8%	19 %	10 %	15 %	46 %	7 %
2014/2015	70	57 %	36 %	9 %	6%	21 %	17 %	21 %	19 %	4 %

Major risks caused cost overrun and delaying time in waste water projects are shown in Table 4. For example, defective design affected 54 projects of 80 projects in 2010/2011; it caused 1.2 million Egyptian Pounds (LE) cost overrun and 4.8 years delaying time. In 2012/2013 gaps between the implementation and specifications affected 35 projects out of 100 projects; it caused 1.5 million LE cost overrun and 2.4 years delaying time. From Table.3, "Defective design" risk is the most effective risk of major risks; it affected between 25 and 54 of waste water projects annually from 2010 to 2015. "Defective design" risk caused cost overruns about 1.14 million LE annually and 4 years delaying time in average. "Defective design" risk is depending on the efficiency of design team or the consultant.

ISSN 2229-5518

Table 4

Cost overrun and delaying time caused by major risks through study years (2010 - 2015)

2012/2013			2011/2012			2010/2011		Year		2014/2015			2013/2014		
Cost x 106 LE	No. of projects	Time (years)	Cost x 106 LE	No. of projects	Time (years)	Cost x 106 LE	No. of projects	Risk factors	Time (years)	Cost x 106 LE	No. of projects	Time (years)	Cost x 106 LE	No. of projects	Time (years)
1.2	50	3.6	0.9	33	4.8	1.2	54	Defective design	3	0.9	25	4.2	1.5	50	4.2
0.15	30	2.4	0.06	18	3	0.12	18	Not coordinated design	1.8	0	6	3	0.12	25	3.6
0.09	11	1.8	0.09	14	1.8	0.12	18	Difficulty to get permits	1.2	0.06	4	2.4	0.12	10	1.2
1.5	35	1.8	0.6	20	3	1.2	35	Gaps between Implementation and spe-	2.4	0.3	15	2.4	0.6	25	2.4
1.2	27	1.2	0.6	15	1.8	0.9	27	Design changes	1.2	0.6	12	1.2	0.6	13	1.8
0.3	27	0.9	0.12	7	1.2	0.3	18	Poor communication between involved	0.9	0.3	15	1.2	0.3	20	1.8
0.15	18	0.6	0.06	6	0.9	0.1	16	Changes in management ways	0.6	0.06	7	0.9	0.12	18	1.2
0.18	10	0.6	0.18	7	0.9	0.3	15	Information unavailability	0.6	0.12	3	0.6	0.15	9	0.6
4.77		12.9	2.61		17.4	4.24		Total	11.7	2.34		15.9	3.51		16.8

4.1 Risk Impact on Project Cost

To improve controlling of cost variation for constructing waste water projects in Egypt; one must identify and recognize the influence of the main factors affecting it (Aziz, 2013). By collecting data from the company document archive, the rate of increasing cost in waste water projects due to the 8 major risk factors is about 3.5 million LE, in average, annually, as shown in Figure2. The rate of cost overrun was varying irregularly through the study years. The highest cost overrun due to risk factors was 4.77million LE during 2012 /2013, about 60% of waste water projects were affected by risk. In 2014 / 2015 the percentage of projects that were affected by risk was 57%, which caused cost overrun of about 2.34 million LE. During 2012 / 2013 an increase in risky projects percentage was noticed, by 3% difference, from 2014 / 2015 which is quite small difference while the cost overrun increased by 2.43 million LE more than that of 2014 / 2015. The cost overrun does not depend on the number of projects only, but also depends on the cost of the projects and the degree of risk affecting. Projects with expensive budget are exposed to more cost overruns due to more risk exposure.

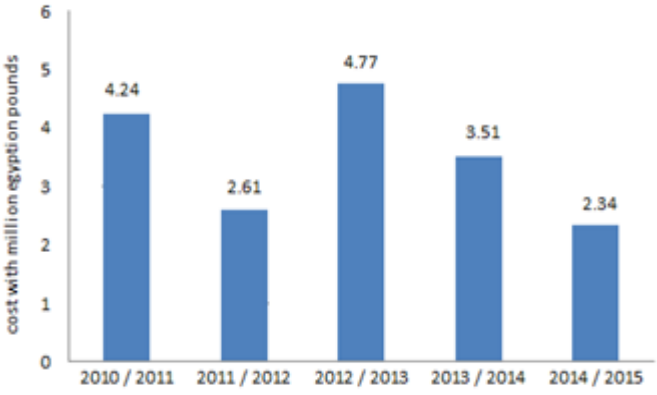

Figure2: Cost overrun due to the 8 risk factors from 2010 to 2015

It is noticed from Table 5 that the technical risks, such as "defective design" risk, have a high impact on the project's cost. Through the study period, "Defective design", "Gaps between the implementation and specification" and "Design changes" risks caused cost overrun of about 1.14, 0.84 and 0.78 million LE annually, respectively. However, managerial risks as "Poor communication between parties" risk increased cost overrun by 0.26 million LE annually and considered the largest cost overrun due to managerial risks. Therefore, technical risks cause more cost overrun than the managerial risks in waste water projects.

Table 5
Total cost overruns as an impact of each risk factor from 2010 to 2015

Risk factors	Total increase in cost (million LE)
Defective design	5.7
Gaps between the Implementation and specifications	4.2
Design changes	3.9
Poor communication between involved parties	1.32
Information unavailability	0.93
Changes in management ways	0.49
Difficulty to get permits	0.48
Not coordinated design	0.45

4.2 Risk Impact on Project Time

Table 6

Total delayed time as an impact of each risk factor from 2010 to 2015

Risk factors	Total delay in time (Years)
Defective design	19.8
Not coordinated design	13.8
Gaps between Implementation and specifications	12
Difficulty to get permits	8.4
Design changes	7.2
Poor communication between involved parties	6
Changes in management styles	4.2
Data unavailability	3.3

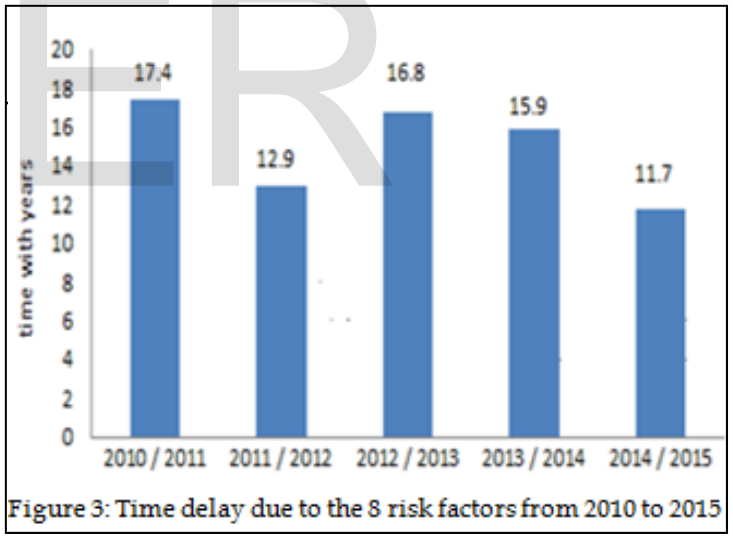

Figure 3: Time delay due to the 8 risk factors from 2010 to 2015

The rate of delaying time of waste water projects annually due to the 8 major risk factors is about 15 years as shown in Figure 3. The rate of delaying time is changing irregularly through the study period. The longest delayed time due to the risk factors was 17.4 years in 2010 /2011 where about 69% of waste water projects were affected by risk. During 2011 / 2012 the delayed time due to the risk factors was 12.9 years where about 83% of waste water projects were affected by risk. Year 2011 / 2012 increased in risky projects percentage from 2010 /2011 with 14% increase, but still 2010 / 2011 has the largest time delaying in waste water projects due to risk factors. The time delaying is not depending on the number of projects only

but also depending on the number of risks affecting on the project.

Through the study period, "Not coordinated design", "Gaps between the implementation and specification" and "Design changes" risks caused delaying time by 13.8, 12 and 7.2 years, respectively. However, managerial risks as "Difficulty to get permits" risk caused delaying time by 8.4 years from 2010 to 2015 and considered the highest time delaying due to managerial risks. Therefore, managerial risks cause more time delaying than the technical risks in waste water projects.

5. CONCLUSIONS AND SUMMARY

Potable and Waste water projects are more sensitive to risk during the implementation stage more than other types of projects. Replacement and renovation type of waste water projects is more affected by risk than the new construction type. The replacement and renovation is used to increase the capacity of the network or the station. The risk impact in waste water projects appears in cost overrun and the project time delay.

The study area was taken in Damietta, Egypt through five years' time frame from 2011 to 2015. By studying and reviewing all the archived documents of the 222 projects. Out of 33 risk factors, 8 major risks factors were identified based on the principal component analysis. "Defective design" risk has the highest effect between the 8 major risk factors in cost and projects time. "Defective design" risk caused costs overrun of about 1.14 million LE yearly and 4 years delaying time in waste water projects. "Defective design" risk is depending on the design team or the consultant. "Defective design" risk doesn't depend on any external factor as; site nature, environment condition and management system. The company should study the risk factor and find solution to decrease its occurrence.

The 8 major risk factors classified to technical risks and managerial risks. Technical risks have major impact on both project time and cost, while managerial risks have more impact on the project time than project cost. Risk impact, not only depend on the number of projects affected by the risk but also depend on several factors such as projects priority, project cost and the degree of risk affecting the project. Risk affects differently in two projects with same condition, budget and time. Projects with high priority and expensive budget are exposed to more impact due to risk.

Technical risks are depending on site problems, such as design and drawing misunderstanding. Technical risks are impact both the cost and project time. Decision maker in the company should give more attention to the design team or choose responsible consultant for the design and site works. Managerial risks are depending on the company strategy in management as the way of giving and receiving orders between projects parties and changing management way. Managerial risks are also depending on relationship between company and other governmental authorities. Managerial risks have major impact on project time. The decision maker in Damietta holding company should review the management way, providing facilities to decrease the effect of managerial risks on both cost and time.

Finally, the Egyptian government should give more attention to potable and waste water projects and increase the approved budget for them. Government should prepare effective plans to cover the rural areas with waste water service. The replacement and renovation of waste water projects are considered the most frequently projects between the company projects. There are some studies must be done to avoid the risk impacts in replacement and renovation type including:

- Cadastral and contour maps to determine the size of the required served area
- Detailed maps of the diameters and depths of the existing network
- Identifying regression lines and expulsion lines.
- Identifying the obstructions such as gas pipes or electrical cables.
- Considering the expected population growth in the future to determine the expansion in stations and network.

REFERENCES

[1] Abdel-Shafy, H., and Aly, R. 2002. Water issue in Egypt: Resources, pollution and protection endeavors. Navigation, 49(3.1), 4-6.

[2] Abdi, H., and Williams, L. J. 2010. Principal component analysis. Wiley Interdisciplinary Reviews: Computational Statistics, 2(4), 433-459.

[3] Arias, J. C. 2011.Review of Risk Management Methods.Volume 4-Number 1-January 2011-Semiannual Publication, 4(1), 59.

[4] Aziz, R. F. 2013. Factors causing cost variation for constructing wastewater projects in Egypt. Alexandria engineering journal, 52(1), 51-66

[5] Bakr, A. F., El Hagla, K., and Rawash, A. N. A. 2012. Heuristic approach for risk assessment modeling: EPCCM application (Engineer Procure Construct Contract Management). Alexandria Engineering Journal, 51(4), 305-323.

[6] Bedford, T., and Cooke, R. 2001.Probabilistic risk analysis: foundations and methods. Cambridge University Press.

[7] Berg, H. P. 2010. Risk management: procedures, methods and experiences. Risk Manage, 1, 79-95.

[8] Cohen, M. W., and Palmer, G. R. 2004. Project risk identification and management, AACE International

[9] Elsanabary, M. H., and Gan, T. Y. 2014. Weekly streamflow forecasting using a statistical disaggregation model for the Upper Blue Nile basin, Ethiopia. Journal of Hydrologic Engineering, 20(5), 04014064.

[10] Hillson, D. 2003. Effective opportunity management for projects: Exploiting positive risk. CRC Press

[11] Hillson, D. 2006. Integrated risk management as a framework for organizational success. In PMI Global Congress proceedings.

[12] Hubbard, D. W. 2009. The failure of risk management: Why it's broken and how to fix it. John Wiley & Sons.Transaction, pp. I013-15. Retrieved September, 10, 2006.